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X-RAY INVESTIGATION OF THE PYROCHEMICAL CHANGES IN MISSOURI HALLOYSITE*

By Frank J. Zvanut† and Lyman J. Wood‡

Abstract

Results are presented of an X-ray study of the chemical changes that take place during the progressive firing of Missouri halloysite. A General Electric multiple-diffraction unit was used to obtain patterns of samples that had been fired at temperatures ranging from 350 °C to the melting point (about 1800 °C) at 50 ° intervals. Twenty-three of these samples were fired for 12-hour periods, five for 200-hour periods, and a few at the higher temperatures for shorter periods of time. The results seem to indicate the dehydration of the kaolin mineral to be near 450 °C, the precipitation of a modified phase of gamma-alumina at 900 °C, the appearance of mullite at 1150 °C, and the crystallization of cristobalite at about 1350 °C, with its subsequent disappearance above 1500 °C. A short summary of the results of the chemical and petrographic studies which were made with the X-ray study is appended.

I. Introduction

For centuries it has been known that the application of heat to a clay or a clay body produces changes that make it an entirely different substance from the original raw clay. Ever since the earliest civilizations produced crude building brick by baking formed clay bodies in the sun's rays, mankind has been speculating on the nature of the changes that convert soft, friable, plastic clays into hard, strong, nonplastic, rock-like masses. It has been only within the last two decades, however, that progress has been made in the solution of the problems dealing with the resultant products in fired clay bodies. The development of the petrographic microscope and the technique for crystal analysis by X-ray methods have supplied impetus to numerous investigations dealing with the chemical reactions involved and the crystalline compounds developed in clays on firing. These tools, in the hands of competent investigators, have produced some excellent results.

Most of the investigations have been on clays of the kaolin type and, in many cases, on impure varieties. Previous to the work of Ross and Kerr[1] on the kaolin minerals, little was known about the mineralogical composition even of the purest clays or of the nature of the minerals that compose the kaolin group. Their classification of the clay minerals (nacrite, dickite, kaolinite, and halloysite) as individual members of the kaolin group has created a broader field for research in the pyrochemical behavior of clays, because it has been shown that the kaolin minerals, especially the last two, are often associated with each other in all types of clays. Before the reactions that take place during the firing of a complex clay or clay body can be thoroughly understood, it is imperative that the pyrochemical behavior of each one of the clay minerals be studied.

II. Purpose

A number of investigations have been made dealing with the effect of heat on china clays and kaolins, which are composed essentially of kaolinite, but heretofore none has been made on the pyrochemical behavior of halloysite, dickite, or nacrite.

In a preliminary report[2] one of the authors has described a deposit of halloysite occurring in Lawrence County, Missouri, and has presented a discussion of its physical and chemical properties. In a later report,[3] the results of a petrographic, chemical, and X-ray investigation of the effect of heat on halloysite from this locality were presented. These papers contain thorough reviews of the literature on the subject of the clay minerals

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[1] (*a*) C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, **165**, pp. 151–76 (1930); *Jour. Amer. Ceram. Soc.*, **13** [3] 151–60 (1930).

(*b*) C. S. Ross and P. F. Kerr, "Halloysite and Allophane," *U. S. Geol. Surv. Prof. Paper*, **185G**, pp. 135–48 (1934); *Ceram. Abs.*, **14** [4] 101 (1935).

[2] F. J. Zvanut, "Notes on Missouri Halloysite," *Jour. Amer. Ceram. Soc.*, **20** [3] 84–87 (1937).

[3] F. J. Zvanut, T. W. Schrenk, L. J. Wood, and C. M. Dodd, "Pyrochemical Changes in Missouri Halloysite," *Univ. of Mo. School of Mines and Metallurgy Bull.*, **12**, No. 3 (March, 1937).

and their firing behavior, with an extensive bibliography; therefore this material is not included in the present report.

The results of the X-ray investigation of the pyrochemical behavior of Missouri halloysite and a short summary of the results of the complete study are presented here.

III. Preparation of Halloysite Samples

Clean, white material, containing some very fine grit but comparatively free from iron, was obtained by hand-picking from a 100-pound sample of Missouri halloysite. The chemical analysis of the material, as mined, was as follows:

SiO_2	44.10%	Alkalis	0.14 (%)
Al_2O_3	37.99	H_2O −105°C	3.17
Fe_2O_3	0.51	Ignition loss	14.09
CaO	0.15		
MgO	0.09	Total	100.24

SiO_2/Al_2O_3 1.99/1.00

D. M. Long, Missouri Bureau of Geology and Mines, Analyst.

The clay was ground by passing it through rolls and a disk disintegrator, and a magnet was used to remove any contaminating iron particles. The sample was quartered down to about ten pounds and ground with a porcelain mortar and pestle so that all of it passed a 100-mesh sieve.

The halloysite was mixed with water and pugged to the proper consistency for good workability, and small cylindrical rods, approximately $^3/_8$ inch in diameter and 2 inches long, were formed by extrusion through a piece of glass tubing. These were dried in air at room temperature for 24 hours and then in the drier at 110°C for an additional 24-hour period, after which they were kept in a dessicator until the firing.

For firing, the rods were mounted in sets of four on cone plaques, such as are ordinarily used for pyrometric cone equivalent determinations. These plaques were fired individually at different temperatures as follows: twenty-three plaques at 50° intervals between 350° and 1450°C for 12 hours each; five at 365°C, 400°C, 900°C, 950°C, and 1000°C, respectively, for 200 hours each; one at 1500°C for six hours; one at 1620°C for three hours; and another at 1800°C, at which point the halloysite melted. In each case the specimens were removed from the furnace upon completion of the firing and cooled in air to room temperature.

A nichrome-wound electric-resistance furnace was used for firing up to 1000°C, and a Fulton-Coursen "grananular" carbon-resistance furnace was used for firings at the higher temperatures. The rate of temperature increase was approximately 300°C per minute. Shorter firing times were used at the highest temperatures because of the difficulty of controlling the furnace above 1500°C for any length of time. The temperatures were controlled by rheostats, recorded by a potentiometer, using a platinum platinum-10% rhodium thermocouple, and held constant to within ten degrees as much as possible after the desired temperature had been attained.

IV. X-Ray Apparatus and Procedure

A General Electric X-ray diffraction apparatus[4] was used for the X-ray study of the pyrochemical behavior of Missouri halloysite.

The powder method of crystal analysis[5] was used, and diffraction patterns were made of each of the fired halloysite samples and of samples of the known substances, corundum, kaolinite, indianaite, Missouri halloysite, quartz, mullite, and sillimanite. The molybdenum target Coolidge tube was operated at about 14 milliamperes and 30 kilovolts. Forty-eight hour exposures were used in every case, and four patterns were obtained on each run with this multiple-diffraction unit. Sodium chloride was used as a reference material, and a calibrated scale was used to determine the values of the interplanar spacings represented on the patterns.

V. Data

The first four tables list the values of interplanar spacings and the relative intensities of the lines of the diffraction patterns of the several reference materials needed in this study. All were obtained from the cited literature, and some were checked during the course of the investigation.

Table V gives similar data for the diffraction patterns of Missouri halloysite fired to the indicated temperatures. These data represent the average of three measurements and observations.

NOTE: All patterns in Table V, with the exception of pattern 15-A, were made using the diffraction apparatus at St. Louis University; pattern 15-A was made using a demountable tube with an iron target at the School of Mines and Metallurgy, Rolla, Mo.

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[4] This apparatus was made available through the courtesy of L. F. Yntema and L. J. Wood, Chemistry Department of St. Louis University.

[5] W. P. Davey, "Study of Crystal Structure and Its Applications: The Powder Method of Crystal Analysis," *Gen. Elec. Rev.*, **28**, 586–99, 721–30 (1925); **29**, 118–28 (1926).

Because of the construction of the cameras and the wave-lengths of the radiations used, lines representing spacings greater than 6.5Å could not be obtained. In some cases, the effect of general radiation and the very faint quality of lines made accurate measurements practically impossible, and careful inspection under proper lighting conditions was necessary.

VI. Discussion of Results in Table V

Pattern (1)

Missouri halloysite dried at 125°C for 24 hours. Mehmel,[6] working with a clay that originally contained four molecules of water, noticed that drying at 50°C removed two molecules of the montmorillonite on drying. Inasmuch as Mehmel had called his original material halloysite, he named the dried product "metahalloysite." Inspection of his patterns (Table I, patterns (3) and (4)) shows a marked difference in the interplanar spacings of higher values. Missouri halloysite loses about 3% water on drying; this represents about one-fourth of a molecule. No difference was noted in the patterns made before and after drying the Missouri clay.

The pattern of Missouri halloysite is similar to that of Mehmel's metahalloysite and to the patterns of halloysite obtained by other investigators (see Table I). Ross and Kerr (pattern (2), Table I) list lines at 3.97Å and 1.510Å, but these

TABLE I

X-RAY DIFFRACTION PATTERNS OF HALLOYSITE

Pattern (1)		Pattern (2)		Pattern (3)		Pattern (4)		Pattern (5)		Pattern (6)		Pattern (7)	
(*d*)	(*I*)	(*d*)	(*I*)	(*d*)	(*I*)	(*d*)	(*I*)	(*d*)	(*I*)	(*d*)	(*I*)	(*d*)	(*I*)
						10.10	(*ss*)						
		7.42	(*m*)	7.46	(*s*)			7.48	(*m*)				
4.42	(*s*)	4.42	(*s*)	4.43	(*s*)	4.46	(*s*)	4.44	(*s*)	4.45	(*s*)	4.41	—
		3.97	(*mf*)										
3.61	(*f*)	3.63	(*m*)	3.63	(*m*)			3.62	(*f*)	3.65	(*m*)		
						3.40	(*m*)						
3.32	(*f*)							3.35	(*f*)				
2.55	(*f*)	2.56	(*m*)	2.55	(*m*)	2.56	(*m*)	2.60	(*s*)	2.60	(*m*)	2.56	(*s*)
												2.508	(*m*)
2.34	(*f*)	2.365	(*m*)	2.32	(*m*)	2.37	(*mf*)	2.33	(*s*)	2.35	(*m*)	2.337	(*m*)
						2.23	(*mf*)						
1.67	(*f*)	1.685	(*m*)	1.67	(*mf*)	1.67	(*mf*)	1.70	(*m*)	1.69	(*f*)	1.64	(*f*)
								1.64	(*m*)				
		1.510	(*s*)										
1.485	(*s*)			1.48	(*m*)	1.48	(*m*)	1.487	(*s*)	1.48	(*s*)	1.48	(*s*)
1.270	(*f*)	1.295	(*f*)	1.27	(*mf*)	1.285	(*f*)	1.290	(*f*)	1.29	(*f*)	1.29	(*f*)
1.250	(*f*)	1.250	(*f*)	1.23	(*f*)	1.23	(*f*)	1.237	(*f*)	1.24	(*f*)	1.23	(*mm*)

(*d*) Angstrom units
(*I*) estimated intensity
(*ss*) very strong
(*s*) strong
(*m*) medium
(*mf*) medium to faint
(*f*) faint
(*ff*) very faint

Pattern (1) Missouri halloysite, determined in this investigation.
Pattern (2) Belgium halloysite (Ross and Kerr, see footnote 1(*b*), p. 251).
Pattern (3) M. Mehmel, "Structures of Halloysite and Metahalloysite" (Über die Struktur von Halloysit und Metahalloysit), *Z. Krist.*, **90**, 35–43 (1935); *Ceram. Abs.*, **14** [11] 291 (1935).
Pattern (4) Halloysite (M. Mehmel, *ibid.*).
Pattern (5) Halloysite, G. Nagelschmidt, "X-Ray Investigation of Clays: I, X-Ray Diagrams of Some Clay Minerals; II, Mineral Composition of Clay from Malliss" (Röntgenographiche Untersuchungen an Tonen), *Z. Krist.*, **87** [1–2] 120–45 (1934); *Ceram. Abs.*, **14** [4] 100 (1935).
Pattern (6) Halloysite, W. P. Kelley, W. H. Dore, and S. M. Brown, "Nature of the Base-Exchange Materials of Bentonites, Soils, and Zeolites as Revealed by Chemical Investigations and X-Ray Analysis," *Soil Sci.*, **31** [1] 25–55 (1931); *Ceram. Abs.*, **10** [4] 305 (1931).
Pattern (7) Halloysite, S. B. Hendricks and W. H. Fry, "Results of X-Ray and Microscopical Examination of Soil Colloids," *Soil Sci.*, **29**, 457 (1930).

water and produced a corresponding change in the X-ray diffraction pattern, indicating a shrinkage of the lattice. Hoffman[7] and his associates had previously noticed the lattice shrinkage of

have not been listed by the other investigators; nor were these lines listed by Mehmel for the patterns of halloysite or metahalloysite, which he made and checked by calculations from the assigned space groups. On the other hand, a strong line, which is not recorded by Ross and Kerr, appears at 1.480Å in the patterns of the Missouri material and other halloysite samples.

[6] M. Mehmel, see footnote for pattern (3), Table I.
[7] U. Hoffman, K. Endell, and D. Wilm, "Crystal Structure and the Swelling of Montmorillonite," *Z. Krist.*, **86** [5–6] 340–48 (1933); *Ceram. Abs.*, **14** [4] 100 (1935).

The presence of quartz grains in Missouri halloysite accounts for the very faint line at 3.32Å; this is the strongest line in the quartz pattern (Table II).

Pattern (2)

This sample was fired at 350°C for 12 hours. This is similar to pattern (1) except that the line at 2.34Å has disappeared. The faint line at 5.45Å is possibly due to an absorption edge caused by the high percentage of general radiation in the beam used. This faint line is found on almost all patterns made in this study.

Pattern (3)

Fired at 365°C for 200 hours. Faint lines appear at 4.05Å and 1.370Å, but some of the less intense lines of the original pattern have disappeared. There is some doubt as to the presence of the very faint line at 4.05Å; it may not be a line at all. The line at 1.370Å, however, is probably another quartz line (pattern (1), Table II).

TABLE II. X-RAY DIFFRACTION PATTERNS OF QUARTZ AND CRISTOBALITE

Pattern (1) Quartz* (d)	(I)	Pattern (2) Cristobalite† (d)	(I)	Pattern (1) Quartz* (d)	(I)	Pattern (2) Cristobalite† (d)	(I)
4.25	(m)	5.00	(f)	1.805	(s)	2.025	(f)
3.32	(ss)	4.05	(ss)	1.658	(m)	1.933	(f)
2.44	(f)	3.15	(m)	1.531	(s)	1.873	(f)
2.27	(m)	2.85	(m)	1.430	(f)	1.747	(ff)
2.22	(ff)	2.48	(s)	1.410	(f)	1.695	(f)
2.13	(f)	2.35	(ff)	1.370	(ss)	1.612	(m)
2.05	(ff)	2.20	(ff)	1.280	(f)	1.574	(ff)
1.975	(f)	2.12	(f)	1.250	(f)	1.527	(f)
				1.222	(f)	1.499	(f)

* Quartz pattern obtained in this investigation, using potters' flint.

† Cristobalite pattern. T. F. W. Barth, "Cristobalite Structures: II, Low Cristobalite," *Amer. Jour. Sci.*, [5] **24**, 97–110 (1932); *Ceram. Abs.*, **12** [1] 20–21(1933).

Pattern (4)

Fired at 400°C for 12 hours. The lines are less dense and some have completely disappeared, showing that dehydration is breaking down the crystalline structure.

Pattern (5)

Fired at 400°C for 200 hours. Three faint, diffuse lines, only one of which belongs to the original halloysite pattern, are present.

Patterns (6) to (12)

Patterns (6) and (7) show two lines, one of which is due to the quartz present and the other to the residual halloysite. Above 500°C, halloysite is no longer present as such, and patterns (8) to (11) show only a very faint line, due to the quartz, at 3.32Å. Pattern (12), made of halloysite that had been fired at 900°C for 12 hours, is free of all lines.

Patterns (13)

Fired at 900°C for 200 hours. The increased time of firing at this temperature has brought out several faint lines, the strongest of which is recorded at 1.395Å; the other lines are almost too faint for reliable measurements. The 1.395Å line indicates the presence of beta-alumina (Table III, pattern (2)), or possibly gamma-alumina (Table III, pattern (3)). Inasmuch as it is a known fact that beta-alumina is produced only at very high temperatures, it was decided to call the material a "modification" of gamma-alumina.[8]

TABLE III. X-RAY DIFFRACTION PATTERNS OF CORUNDUM AND BETA- AND GAMMA-ALUMINA*

Pattern (1) Corundum (d)	(I)	Pattern (2) Beta-Alumina (d)	(I)	Pattern (3) Gamma-Alumina (d)	(I)
3.48	(s)	2.82	(s)	2.86	(m)
2.55	(ss)	2.69	(ss)	2.75	(m)
2.38	(s)	2.52	(s)	2.57	(ff)
2.08	(ss)	2.42	(s)	2.45	(s)
1.741	(s)	2.37	(m)	2.33	(m)
				2.25	(m)
1.600	(ss)	2.25	(s)	2.03	(s)
1.540	(f)	2.14	(s)	1.908	(f)
1.510	(m)	2.03	(s)	1.800	(f)
1.404	(s)	1.936	(s)	1.624	(ff)
1.372	(s)	1.834	(m)	1.541	(m)
1.239	(s)	1.743	(f)	1.486	(f)
1.192	(m)	1.654	(m)	1.447	(f)
1.147	(m)	1.594	(s)	1.388	(s)
1.124	(m)	1.569	(s)		
1.099	(m)	1.484	(m)		
1.077	(m)	1.415	(s)		
1.041	(s)	1.393	(ss)		
0.998	(m)	1.344	(s)		
0.933	(f)	1.241	(m)		
0.908	(m)	1.208	(f)		
0.899	(f)	1.170	(ff)		

* W. C. Hansen and L. T. Brownmiller, "Equilibrium Studies on Alumina and Ferric Oxide and on Combination of These with Calcium Oxide," *Amer. Jour. Sci.*, [5] **15**, 225–42 (1928); *Ceram. Abs.*, **7** [5] 320–21 (1928).

NOTE: Corundum pattern was checked in this investigation.

Pattern (14)

Fired at 950°C for 12 hours. One line at 1.395Å is visible.

[8] E. J. W. Verwey, "Structure of the Electrolytical Oxide Layer on Aluminum," *Z. Krist.*, **91**, 317–20 (1935). (Authors' Note: Verwey described the existence of a modified form of gamma-alumina, which he considers as the first step in the progress of crystallization from the amorphous to the completely arranged state. According to him, all kinds of intermediate arrangements exist between these two states.)

Pattern (15)

Fired at 950°C for 200 hours. The increased time of firing at this temperature has brought out most of the lines of pattern (13) and, in addition, three new lines.

Pattern (15-A)

Fired at 950°C for 200 hours. This pattern was made using the iron radiation of the X-ray diffraction apparatus at the School of Mines and Metallurgy. The results show fair agreement with the pattern made using molybdenum radiation.

Patterns (16) to (19)

These patterns show one line at 1.395Å; pattern (19), however, began to show indications of other lines.

Pattern (20)

Fired at 1150°C for 12 hours. The line at 1.395Å has disappeared, but thirteen new lines are present. These check closely with those of mullite (Table IV, pattern (1)).

Pattern (21)

Fired at 1200°C for 12 hours. The lines on this pattern are more clearly defined and check the mullite pattern very well.

Pattern (22)

Fired at 1250°C for 12 hours. This pattern was made using natural sillimanite as the standard for comparison in place of common salt. The direct comparison clearly showed that the material in the fired halloysite was mullite and not sillimanite, as has been suggested in some investigations of the clay minerals.

Pattern (23)

Fired at 1300°C for 12 hours. This pattern checks with that for mullite.

Pattern (24)

Fired at 1350°C for 12 hours. In addition to the mullite lines, two lines, 4.05Å and 1.625Å, which are identified as cristobalite lines (Table II, pattern (2)) are present.

Patterns (25) to (27)

These patterns clearly show the presence of mullite and cristobalite in the fired clay. Four lines can be definitely assigned to the cristobalite pattern, and inspection of the pattern itself shows marked broadenings in some of the mullite lines, owing to certain corresponding cristobalite lines.

Pattern (28)

Fired at 1620°C for three hours. The cristobalite lines have disappeared, but a good mullite pattern remains.

Pattern (29)

Fired to melting at 1800°C. This pattern checks the mullite pattern of Table IV.

TABLE IV. X-RAY DIFFRACTION PATTERNS OF MULLITE AND SILLIMANITE*

Pattern (1) Mullite (*d*)	(*I*)	Pattern (2) Sillimanite (*d*)	(*I*)	Pattern (1) Mullite (*d*)	(*I*)	Pattern (2) Sillimanite (*d*)	(*I*)
3.411	(*s*)	3.411	(*s*)	1.833	(*ff*)	1.833	(*ff*)
2.88	(*f*)	2.89	(*f*)	1.696	(*m*)	1.687	(*m*)
2.691	(*f*)	2.683	(*f*)	1.592	(*ff*)	1.596	(*f*)
2.541	(*m*)	2.543	(*m*)			1.561	(*f*)
2.42	(*ff*)	2.41	(*ff*)	1.518	(*m*)	1.518	(*m*)
2.28	(*f*)	2.27	(*f*)	1.436	(*f*)	1.441	(*m*)
2.20	(*m*)	2.194	(*m*)	1.394	(*ff*)	1.393	(*ff*)
2.116	(*f*)	2.112	(*f*)	1.328	(*m*)	1.326	(*m*)
		1.97	(*ff*)	1.260	(*m*)	1.272	(*f*)
1.889	(*ff*)	1.875	(*ff*)			1.250	(*f*)

* R. W. G. Wyckoff, J. W. Greig, and N. L. Bowen, "X-Ray Diffraction Patterns of Mullite and Sillimanite," *Amer. Jour. Sci.*, [5] **11**, 459–72 (1926); *Ceram. Abs.*, **5** [8] 260 (1926).

NOTE: These patterns were checked in this investigation.

VII. Conclusions

The following conclusions appear to be justified:

(1) The diffraction pattern of Missouri halloysite corresponds with those of most of the other investigators and with the pattern of metahalloysite.[9]

(2) Missouri halloysite contains a small amount of silica present as quartz.

(3) Missouri halloysite is completely dehydrated by firing at 550°C for 12 hours.

(4) The degree of temperature and the duration of the firing are, within limits, inverse functions of each other; prolonged firing at a slightly lower temperature gives the same results as a comparatively short firing period at a higher temperature.

(5) Around 900°C there is evidence of the development of a crystalline phase of alumina which is probably a modified form of gamma-alumina.

(6) The maximum amount of this modified form of gamma-alumina is obtained by firing the clay at 950°C for 200 hours.

[9] M. Mehmel and C. Correns, "On the Optical and X-Ray Proof of Kaolin, Halloysite, and Montmorillonite" (Über den Optischen und Röntgenographichen Nachweis von Kaolinit, Halloysit, und Montmorillonit), *Z. Krist.*, **94**, 337–49 (1935); see also footnote for pattern (3) Table I.

TABLE V

X-RAY DIFFRACTION PATTERNS OF FIRED SAMPLES OF MISSOURI HALLOYSITE

Pattern No.	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(13)		(15)		(15-A)	
Temp. °C	125		350		365		400		400		450		500		900		950		950	
Time (hr.)	12		12		200		12		200		12		12		200		200		200	
	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)
			5.45	(vf)			5.40	(vf)	5.40	(vf)					3.38	(vf)	3.32	(vf)		
	4.42	(s)	4.42	(ss)	4.42	(s)	4.42	(m)	4.38	(vf)	4.42	(vf)	4.43	(vf)	3.02	(vf)			3.104	(m)
					4.05	(vf)									2.77	(vf)				
	3.61	(vf)	3.60	(s)	3.63	(s)	3.62	(m)							2.58	(vf)	2.55	(vf)		
																			2.672	(m)
	3.32	(vf)	3.36	(vf)			3.35	(vf)	3.35	(vf)	3.35	(vf)	3.35	(vf)			2.42	(vf)	2.428	(m)
	2.55	(vf)	2.57	(m)			2.58	(vf)									2.07	(vf)	2.141	(m)
	2.34	(vf)													1.97	(vf)	1.98	(vf)	1.997	(vf)
	1.67	(vf)	1.675	(m)			1.68	(vf)							1.84	(vf)			1.848	(s)
	1.485	(s)	1.485	(s)	1.482	(s)	1.485	(vf)									1.60	(vf)		
					1.370	(vf)	1.372	(vf)											1.538	(vf)
	1.27	(vf)	1.29	(vf)	1.275	(vf)	1.285	(vf)							1.395	(m)	1.395	(m)	1.395	(ss)
	1.25	(vf)	1.24	(vf)	1.235	(vf)	1.22	(vf)												

Pattern (3), film overdeveloped and difficult to read accurately.

Patterns (8) to (11), inclusive, made on samples fired for 12 hours at 550, 600, 650, and 700°, respectively, showed only the quartz line at 3.32Å.

Pattern (12), sample fired at 900°C for 12 hours showed no visible lines.

Pattern No.	(20)		(21)		(22)		(23)		(24)		(25)		(26)		(27)		(28)		(29)	
Temp. °C	1150		1200		1250		1300		1350		1400		1450		1500		1620		1800	
Time (hr.)	12		12		12		12		12		12		12		6		3			
	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)	(d)	(I)
	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)	5.45	(vf)
									4.05	(s)	4.05	(s)	4.11	(s)	4.11	(s)				
	3.38	(s)	3.41	(s)	3.40	(s)	3.38	(s)	3.41	(s)	3.39	(s)	3.41	(s)	3.40	(ss)	3.40	(ss)	3.40	(ss)
	2.86	(vf)	2.89	(vf)	2.88	(vf)	2.84	(vf)	2.89	(vf)	2.85	(vf)	2.88	(m)	2.88	(m)	2.88	(m)	2.88	(m)
	2.69	(vf)	2.69	(vf)	2.69	(vf)	2.68	(vf)	2.70	(m)	2.68	(m)	2.69	(m)	2.69	(m)	2.69	(m)	2.69	(m)
	2.52	(m)	2.52	(m)	2.53	(vf)	2.54	(m)	2.54	(m)	2.50	(m)	2.52	(m)	2.54	(m)	2.54	(s)	2.54	(s)
			2.42	(vf)	2.42	(vf)														
			2.28	(vf)	2.28	(vf)			2.28	(vf)	2.28	(vf)			2.28	(vf)	2.28	(vf)	2.28	(vf)
	2.19	(vf)	2.20	(m)	2.20	(m)	2.18	(m)	2.20	(m)	2.19	(m)	2.20	(m)	2.20	(m)	2.20	(m)	2.20	(m)
	2.09	(vf)	2.12	(vf)	2.12	(vf)	2.11	(vf)	2.12	(vf)	2.12	(vf)	2.12	(vf)	2.12	(vf)	2.12	(vf)	2.12	(vf)
			1.87	(vf)	1.87	(vf)	1.86	(vf)	1.87	(vf)	1.875	(vf)	1.88	(vf)	1.88	(vf)	1.88	(vf)	1.88	(vf)
			1.84	(vf)	1.82	(vf)	1.83	(vf)	1.83	(vf)	1.83	(vf)	1.83	(vf)	1.83	(vf)	1.83	(vf)	1.83	(vf)
	1.69	(vf)	1.695	(vf)	1.698	(m)	1.697	(vf)	1.69	(vf)	1.69	(vf)	1.69	(m)	1.69	(m)	1.69	(m)	1.69	(m)
									1.625	(vf)	1.625	(vf)	1.625	(vf)	1.625	(vf)				
	1.587	(vf)	1.59	(vf)	1.595	(vf)	1.59	(vf)	1.59	(vf)	1.595	(vf)	1.595	(vf)	1.595	(vf)	1.59	(vf)	1.59	(vf)
	1.52	(m)	1.52	(m)	1.521	(m)	1.515	(m)	1.52	(s)	1.52	(s)	1.52	(m)	1.52	(m)	1.52	(m)	1.52	(m)
	1.441	(vf)	1.435	(vf)	1.442	(vf)	1.437	(vf)	1.438	(s)	1.438	(m)	1.44	(m)	1.44	(m)	1.44	(m)	1.44	(m)
	1.391	(vf)			1.40	(vf)			1.397	(vf)	1.40	(vf)	1.40	(vf)	1.40	(vf)	1.40	(vf)	1.39	(vf)
	1.331	(vf)	1.325	(vf)	1.325	(vf)	1.324	(vf)	1.330	(vf)	1.33	(vf)	1.33	(vf)	1.33	(vf)	1.33	(vf)	1.33	(vf)
	1.265	(vf)	1.27	(vf)	1.275	(vf)			1.270	(vf)	1.275	(vf)	1.275	(vf)	1.275	(vf)	1.275	(vf)	1.27	(vf)
					1.262	(vf)	1.262	(vf)			1.255	(vf)	1.255	(vf)	1.253	(vf)	1.255	(vf)	1.26	(vf)
			1.183	(vf)			1.180	(vf)			1.235	(vf)	1.235	(vf)	1.235	(vf)	1.235	(vf)	1.23	(vf)
			1.092	(vf)																

Patterns (14), (16), (18), and (19) made of material heated for 12 hours at 950, 1000, 1050, and 1100°C, and pattern (17), made of material heated at 1000° for 200 hours, show only a faint line at 1.395Å.

(7) On firing Missouri halloysite above 1100°C, mullite begins to form as the modified phase of gamma-alumina disappears.

(8) Cristobalite appears on firing the clay above 1350°C, and remains, together with the mullite, until at a temperature between 1500°C and 1620°C, it disappears.[10]

(9) Sillimanite is never present at any stage in the firing of halloysite.

VIII. Addenda

In addition to the X-ray investigation of the fired halloysite samples, studies were made of their solubility in an acid-alkali treatment and of their indices of refraction, during the course of the chemical and petrographic investigations. It is interesting to note that while the X-ray data showed the gradual elimination of crystalline material on heating up to 900°C, the chemical solu-

[10] N. L. Bowen and J. W. Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, 7 [4] 238–54; [5] 410 (1924). (Authors' Note: Above 1545°C, cristobalite disappears, and mullite is the only crystalline phase present.)

bility data and the refractive indices pointed to the formation of a new alumina-silica compound near 550°C. Similar compounds have been observed in kaolinite by Rinne[11] and McVay.[12] A detailed report of the chemical and petrographic phases of the investigation, which checked the X-ray very well, has been published elsewhere[13] along with the material in this paper.

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[11] F. Rinne, "An X-ray Study of Calcined Calcite, Dolomite, Kaolinite, and Mica," *Z. Krist.*, **61**, 113–24 (1925).

[12] T. N. McVay, "Effect of Temperature on the Optical Properties of Kaolinite," *Jour. Amer. Ceram. Soc.*, **11** [4] 224–26 (1928).

[13] See footnote 3, page (251).

THE SIGNIFICANCE OF PARTICLE SIZE WITHIN THE CLAY FRACTION*

By R. H. Bray

Abstract

The method of Steele and Bradfield for the determination of particle-size distribution, which gives five size fractions within the clay fraction, has been applied to some ceramic clays. Each clay is found to have a characteristic size-distribution curve. Wide variations in size distribution within clays containing similar amounts of clay ($< 1\ \mu$ material) are found. One of the possible practical uses of this type of study is in the blending of clays either to produce a new product having the desired qualities or to reproduce a natural clay.

I. Introduction

It has been the custom up to recent times to regard the clay fraction of a shale, kaolin, ball clay, or other similar ceramic material as a single fraction and to study it from this viewpoint. The results have admittedly not been entirely satisfactory, for the variations in the properties of two different materials, possessing the same amount of clay smaller than 1 or 2 microns in diameter, for example, can be so wide that a study of the material within the smaller than 1 micron material becomes necessary. In short, the clay content value gives no information concerning the size distribution within the clay, the mineral nature of the smaller sizes, or the chemical nature of the different size fractions within the clay material.

Recently, in a paper with Grim and Kerr,[1] the writer has described a method for pretreating the clay and fractionating it into four fractions, (1) a residue larger than $1\ \mu$ in size, (2) a fraction from $1\ \mu$ to $0.1\ \mu$ in diameter, (3) a fraction 0.1 to about $0.06\ \mu$ in diameter, and (4) a fraction smaller than $0.06\ \mu$ in diameter. The fractionation of the $<1\ \mu$ colloid was accomplished by means of the supercentrifuge, run at 40,000 revolutions per minute by varying the rate of flow of the solution through the centrifuge. This method gave practically quantitative data on the amounts of the various sizes and, in addition, gave sufficient amounts of each fraction for a complete study of their chemical, petrographic, and X-ray properties. The results secured removed any doubt as to the crystalline nature of the finest colloid fractions. They also showed the inadequateness of the usual clay examination where fractionated material is not used. Minerals were found which were not originally indicated by the ordinary methods, because they were masked by the larger amounts of the dominant minerals present. Neither the petrographic nor X-ray studies of the whole clay indicates, for example, the presence of beidellite when either the sericite-like clay mica or kaolinite is the dominant mineral.

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[1] R. H. Bray, R. E. Grim, and Paul F. Kerr, "Application of Clay Mineral Technique to Illinois Clay and Shale," *Bull. Geol. Soc. Amer.*, **46** [12] 1909–26 (1935); *Ceram. Abs.*, **15** [5] 163 (1936).

In a later paper by Grim, Bray, and Bradley,[2] the mineral constitution of bond clays is taken up, based on studies using the method described. A recent paper by Grim and Bray[3] takes up the mineral constitution of various ceramic clays, and the mineral composition, size distribution, chemical composition, and base-exchange capacity values for thirteen different ceramic clays are given. Such an intensive and thorough method of study is frequently not feasible since it often takes several weeks to make a complete fractionation and study of a single clay.

Where a complete study is not desired but only the size distribution within the clay fraction is wanted, the method described by Steele and Bradfield[4] offers possibilities. The present paper presents the results secured in applying their method to a variety of ceramic clays.

II. Discussion of the Method Used

The method used for determining size distribution is one described by Steele and Bradfield.[4] In this method the sands are removed with a 300-mesh sieve. The finer silts and coarse colloids are determined by the pipette method based on settling velocity according to Stokes' law. The lower practical limit for this method is about 0.5 μ diameter. These investigators have extended the lower practical limit to 0.0625 μ diameter by replacing gravity with centrifugal force. Reference to the original paper can be made for the development of the formula used for the centrifuge determinations which is as follows:

$$t = \frac{n \log \frac{R_2}{R_1}}{3.81\ N^2 r^2 (d_1 - d_2)}$$

Where N = number of revolutions per sec.
r = radius of particle.
d_1 and d_2 = densities of particle and of medium, respectively.
R_1 and R_2 = distances from axis of rotation to surface of suspension and to sampling depth, respectively.
t = time.
n = viscosity of medium.

For the international centrifuge used, $R_1 = 22$ cm. and $R_2 = 24$ cm., when 25 cc. of solution is added to the regular centrifuge tubes, cushioned in the cup with the regular rubber cushion.

In their original method, Steele and Bradfield used two methods of dispersion. One set of samples was pretreated with sodium oxalate and stirred for 15 minutes. Another set was electrodialyzed, saturated with sodium, and stirred for 15 minutes. The first method is questioned by the writers, owing to the probability of an inaccurate correction for the excess sodium oxalate in the finer size range.

The writer also questions the adequacy of the sodium oxalate pretreatment method in view of the results obtained by Winters and Harland[5] and a few results recently secured in this laboratory. Using sodium carbonate as a dispersing agent, Winters and Harland found that complete dispersion was not obtained until after 48 hours of shaking, the dispersion curve becoming asymptotic in about two days.

The writer found that samples given only 15 minutes of stirring, after being saturated with sodium and run immediately, gave lower results than samples given the same treatment followed by seven days of standing before the colloids were determined. Some data on these observations are given in Table I. The difference for standing would be expected to be greater for a material such as the fuller's earth than for the clays lower in fine material.

In the case of Steele and Bradfield's sodium method, however, the treatment given the clay during electrodialysis, previous to saturation with sodium, probably provides the necessary pretreatment to produce good dispersion when their directions are followed. To eliminate electrodialysis, the writer has substituted the leaching of the clay with acid to remove the bases. This is a short pretreatment compared to the long time involved in electrodialysis and does not "condition" the colloids for dispersion as well as does the electrodialysis. A longer time of shaking and allowing the clay to stand in the wet condition is therefore necessary for best results. The pretreatment of all clays for particle-size determinations needs more study, and the method described below can be considered only tentative. It is felt, however, that 24 hours' shaking followed by about a week's standing with occasional shaking by hand should be a minimum pretreatment for most clays.

Another modification for ceramic clays is the

[2] R. E. Grim, R. H. Bray, and W. F. Bradley, "Constitution of Bond Clays and Its Influence on Bonding Properties," *Trans. Amer. Foundrymen's Assn.*, 7 [5] 211–28 (1936).

[3] R. E. Grim and R. H. Bray, "Mineral Constitution of Various Ceramic Clays," *Jour. Amer. Ceram. Soc.*, 19 [11] 307–16 (1936).

[4] J. G. Steele and R. Bradfield, "Significance of Size Distribution in the Clay Fraction," *Rept. Amer. Soil Survey Assn. Bull.*, No. 15, pp. 88–93 (1934); *Ceram. Abs.*, 14 [1] 21 (1935).

[5] Eric Winters and M. B. Harland, "Preparation of Soil Samples for Pipette Analysis," *Jour. Amer. Soc. Agron.*, 22 [9] 771–79 (1930).

use of an extra quantity of sodium hydroxide to insure complete dispersion in materials high in the coarse colloid or very fine silt fraction but low in base-exchange capacity. The total amount of 0.1 *N* NaOH should be not less than 6 cubic centimeters for the 250 cubic centimeters of suspension. The china clays, low in base-exchange capacity but high in material between 0.5 and 10 μ in diameter, may need more NaOH than calculated as required to saturate the base-exchange capacity.

III. Outline of Method

The method of Steele and Bradfield was modified as follows: (1) the bases were removed with 0.1 *N* HCl or 0.5 *N* HAc instead of electrodialysis; (2) the time of shaking and standing after the sample has been saturated with sodium was increased; (3) different time intervals for sampling the settling suspension were used as a matter of convenience; and (4) the 10-micron fraction was determined. The following outline of the method includes the above changes:

A 5-gram sample of clay is leached with 0.1 *N* HCl or 0.5 *N* HAc on a 9-centimeter Buchner funnel, using suction. After leaching with 500 cubic centimeters of the acid, excess acid is removed from the clay by leaching with 500 cubic centimeters of distilled water. The sample is quantitatively transferred to a shaking bottle, an amount of 0.1 *N* NaOH equivalent to the base-exchange capacity is added, and the suspension is made up to about 150 milliliters with distilled water. The bottle is put on a shaking machine for 24 hours, then removed, and occasionally shaken by hand for six days. The suspension is transferred to a 250-milliliter cylinder and made up to volume (250 milliliters). It is then shaken by hand, the time noted, and allowed to stand on a solid desk sheltered from rapid temperature changes. Five cubic centimeter samples are removed from the depths shown in Table II at the corresponding times of settling and placed in tared weighing bottles, rinsing the pipette with distilled water into the bottle. The weighing bottles are dried in the 110° oven, then cooled, and weighed to 0.1 milligram.

In all samplings, stirring of the solution is avoided. The half-micron sample is taken at 2 centimeters just prior to the sampling of the one-micron sample at 8 centimeters.

The following directions for making the centrifuge determinations are quoted from Steele and Bradfield:

"After the last gravity sample was removed, the suspensions were stirred with the machine for a few minutes. Portions of 25 cubic centimeters were placed in centrifuge tubes (100-cc. size) and centrifuged as soon as possible for the required time. Sampling was again carried out as described. Ordinarily four samples were run at one time, each in duplicate. A set of eight tubes was placed in the centrifuge for the 4-minute period of centrifuging, another set for the 17-minute period, etc. The time was taken from the moment the motor was turned on until it was turned off. No correction was applied for differences in the time of acceleration and retardation. The speed was maintained as nearly as possible at 2200 r.p.m., using a vibration tachometer. Care was taken to have tubes and cups exactly balanced, and the centrifuge well lubricated to avoid vibration.

"The temperature was maintained fairly constant by working in a basement room and shielding the bottles from air currents. A correction was applied to the time of sampling if the temperature varied 1 degree or more from 25°C. No special precautions were taken to keep the temperature constant during the process of centrifuging."

TABLE I

EFFECT OF STANDING AFTER PRETREATMENT ON PARTICLE-SIZE RESULTS

	15 min. stirring		15 min. stirring + 7 days' standing	
Clay	<1 μ	<0.5 μ	<1 μ	<0.5 μ
English fuller's earth	54.7	49.0	78.3	72.1
Southern filler clay	38.8	13.1	44.9	22.8
Soil clay 14861*	14.7	10.9	19.9	15.7

* Forty-three days of standing gave no further increase over the 7-day value.

TABLE II

TIME AND DEPTH OF SAMPLING*

Depth of sampling (cm.)	Time (hr.)	(min.)	(sec.)	Equivalent diameter (microns)
		Gravity		
9	0	15	0	10.0
9	1	0	0	5.0
8	5	30	0	2.0
8	22	0	0	1.0
2	22	0	0	0.5
		Centrifuge†		
2		4	17	0.25
2		17	3	0.125
2	1	8	1	0.0625

* Temperature 25°C.
† At 2200 r.p.m. and R_1 = 22 cm.; R_2 = 24 cm.

In the determinations described by Steele and Bradfield, the sample is removed at a depth of 2 centimeters with a 5-cubic centimeter pipette. After the samples are removed, the residues from the 25-cubic centimeter aliquots of each sample

are saved, and after the final size fraction has been determined the residues are returned to the original suspension for the sand determination. This is made by washing the whole suspension through a 300-mesh sieve and collecting, drying, and weighing the sands retained.

(1) Calculation of Results

A separate determination of the oven-dried weight is made on the original clay and the weight of air-dried clay used is corrected to oven-dried weight. Where the sample is diluted to 250 cubic centimeters and 5-cubic centimeter aliquots are removed, the following formula can be used:

$$\frac{250}{5} \times \frac{\text{weight of residue from aliquot}}{\text{oven-dried weight of whole sample}} \times 100 = \text{percentage of material in fraction removed at time, } t.$$

The percentage of each size fraction is calculated as the difference between the values obtained. For example, the fraction smaller than one micron is found to be 10% and the fraction smaller than one-half micron is 8%. The size fraction 1 to 0.5 micron is, therefore, 2%.

Each sample is run in duplicate and one to four samples can be run at one time. In starting the gravity determinations, the samples are started at about 2-minute intervals so that each sample can be tested at exactly the time interval required.

IV. Discussion of Results

The results of the method described are given in Table III and do not include a separation of the coarse silt and sands which can be obtained by use of the 300-mesh sieve. The fraction coarser than 10 μ includes both these fractions. They are omitted, not because they are not of importance to the ceramist, but because the special interest of the writer at the time they were run was in the finer size ranges.

The values for the finer material in clays of the fuller's earth type are probably low, and these results can be considered only tentative, pending further research into the matter of pretreatment of such materials. In spite of a possible lack of full dispersion, the Wyoming bentonite and the English fuller's earth are significantly higher in extremely fine material than the other clays.

TABLE III
PARTICLE-SIZE DATA ON THE CLAYS STUDIED

	>10 μ	10–5 μ	5–2 μ	2–1 μ	1–0.5 μ	0.50–0.25 μ	0.25–0.125 μ	0.125–0.062 μ	<0.062 μ
N. C. china clay	50.4	18.9	7.0	4.1	6.8	9.9	1.3	0.8	0.8
Southern filler clay	12.5	12.3	16.9	13.4	22.1	18.6	2.4	0.5	1.3
Ky. ball clay	13.5	2.7	9.2	10.2	15.4	23.1	12.9	3.3	9.7
Attapulgus fuller's earth	3.7	1.3	0.0	0.0	1.0	14.8	32.7	33.2	13.3
English fuller's earth	n.d.*	n.d.*	n.d.*	n.d.*	6.2	5.5	8.7	7.3	50.6
Olmsted fuller's earth	6.0	6.2	18.3	23.2	19.9	11.6	6.1	0.9	7.8
Wyo. bentonite	5.0	1.0	6.0	5.5	9.4	n.d.*	n.d.*	n.d.*	43.5
Maquoketa shale	27.2	13.0	16.8	9.7	8.1	9.1	6.5	4.1	5.5
Pa. shale	39.5	21.0	16.7	6.7	5.8	3.2	2.3	0.6	4.2
Clay subsoil 14037	45.6	10.7	7.5	3.3	3.8	5.0	4.1	3.6	16.4
Indianaite†	43.5	8.3	9.3	4.1	5.6	9.2	12.4	6.1	1.5
Diaspore†	62.8	15.6	10.3	4.8	3.3	1.0	1.0	0.5	0.7

* n.d. = not determined.
Southern filler clay, a kaolinitic clay according to private communication from R. E. Grim.
The soil clay (14037) is a beidellite-type clay.
The other clays, except the English fuller's earth, are described in a former paper (see R. E. Grim and R. H. Bray, footnote reference 3, p. 258).
† Ground products.

The North Carolina china clay (Table III) is shown to contain very little of the fine colloidal material, *i.e.*, from 0.25 μ down. In contrast, the Kentucky ball clay contains not only a large amount of fine clay but more than 25% of it is smaller than 0.25 μ in diameter while 9.75% is of the smallest size fraction. The southern filler clay is intermediate between the North Carolina china clay and the ball clay in certain respects. Like the china clay, it contains very little extremely fine material, smaller than 0.25 μ in diameter but, like the ball clay, it contains relatively little material larger than 10 μ in diameter. These three clays are all kaolinitic clays and vary in particle-size distribution among themselves sufficiently to make possible many different combinations or blends. With similar data for a wide variety of commercial kaolinitic clays it should be possible to produce, at will, kaolinitic blends having desired characteristics, provided the clays

used are also satisfactory in qualities other than those influenced by particle size.

Shales vary widely in size distribution as shown by a comparison of the Maquoketa and Pennsylvanian shales (Table III). The clay subsoil is relatively high in the $<0.062\ \mu$ fraction, being exceeded only by the Wyoming and English fuller's earths. The diaspore has very little clay and practically no very fine clay. The indianaite occurs as a hard, rock-like material and was ground to pass a 100-mesh sieve. The size distribution is, therefore, not representative of the original material but of the ground product.

The effect of mixing clays on the particle-size distribution of the resulting mix can be calculated from the type of data described here. Calculations have been made on the size-distribution curve for a mixture of three-fourths china clay and one-fourth ball clay. The china clay is significantly modified by the ball-clay addition at only two points: the material coarser than $5\ \mu$ in diameter is decreased about 13%, while the material smaller than $0.5\ \mu$ is increased about 9%. The percentage of intermediate sizes changed very little. On the other hand, three-fourths china clay and one-fourth filler clay decreased the $>10\ \mu$ material by about 9%, while the intermediate sizes (5.0 to 0.25) were increased by about the same amount, having little effect on the very fine range. In short, the ball clay takes away from the coarse end and increases the very fine colloidal portion, while the filler clay serves to decrease the coarse end and increase only the intermediate size fractions.

The data in Table III illustrate the kind of information obtainable from the use of Steele and Bradfield's method. It appears to the writer to be a type of information which will become more and more valuable as the volume of information grows and as certain ceramic properties can be correlated with size distribution within the colloidal size range.

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METHOD FOR IMPROVING THE PHYSICAL PROPERTIES OF CLAYS*

By J. W. Whittemore and F. W. Bull

Abstract

The effect of an organic material, commercially known as Plasticade, on the physical properties of several clays was studied. Plasticade is principally an organic compound with a tannin and lignin base and is an acid in its reactions. It has a marked effect on all of the physical properties of the clays studied. Its effect was studied first in the laboratory and then determined from plant trials.

I. Introduction

Many clays and shales, because of their particular physical properties, are difficult to form by the extrusion methods, difficult to dry and fire without excessive losses, and not sufficiently strong after firing to pass the more rigid specifications for the products. Considerable work has been done on the effect of additions of deflocculating and flocculating agents to clays and shales in the plastic state. According to Searle,[1] Wilson,[2] and others,[3] flocculation of clays may be effected by almost any acid. This action of flocculation of clay by acids tends to agglomerate the clay particles and to affect the physical properties otherwise. According to work by Bleininger and Fulton[4] and Staley,[5] the water of plasticity, the drying shrinkage, and the ease of

* Presented at the Thirty-Eighth Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Structural Clay Products Division).

[1] A. B. Searle, Chemistry and Physics of Clays, p. 244. D. Van Nostrand Co., New York, 1926.

[2] Hewitt Wilson, Clay Technology, p. 64. McGraw-Hill Book Co., Inc., New York, 1927.

[3] (*a*) A. B. Searle, *loc. cit.*, pp. 241 and 245.
(*b*) W. D. Bancroft, Applied Colloid Chemistry, p. 300. McGraw-Hill Book Co., Inc., New York, 1932.

[4] A. B. Searle, *loc. cit.*, p. 270.

[5] H. F. Staley, "The Effect of Salts on the Drying Behavior of Some Clays," *Trans. Amer. Ceram. Soc.*, 17, 697–719 (1915).

forming are altered by additions of acids and various salts.

Plasticade,[6] a product from the paper industry, is an organic, water-soluble material with a lignin and tannin base. It was added to several clays and shales in various amounts. It was found that extremely small amounts, such as 0.10%, 0.125%, and 0.25% (based on the weight of the dry clay) had a marked effect on the clays and shales studied.

Plasticade is an acid in its reactions and, as such, produces a flocculating action when added to clays and shales in very small amounts. As pointed out by Searle,[7] "Some substances which in small proportions cause flocculation will, when added in larger proportions, cause a reverse action. It is necessary, therefore, to ascertain the concentration at which the substance must be employed or added to secure the desired results." It was found by the experiments that Plasticade was a substance which acted in a similar manner when added to clays. To determine the effect of Plasticade, it was tested with several clays and shales in the laboratory and at commercial plants. The laboratory tests included the effect of additions of Plasticade on the following clays, both de-aired and nonde-aired: (1) a Virginia shale, (2) an Ohio sagger clay, and (3) an Ohio sewer-pipe clay.

II. Laboratory Procedure

The Plasticade was added to the clays and shales in a dry, powdered form previous to grinding and tempering the clay. An attempt was made to obtain the best working consistency of the clay batches rather than to control the amount of water added. It was found that when equal amounts of water were added to the clay batches, those containing Plasticade were too soft for satisfactory extrusion. The test specimens were formed by a V-60 Bonnot auger-extrusion machine, equipped with a de-airing unit. A square die, $1^1/_8$ by $1^1/_8$ inches, was used to form the specimen for the determination of water of plasticity, shrinkage water, pore water, shrinkage, strength, and absorption. The test methods[8] used were standards recommended by the American Ceramic Society.

[6] Mead Paperboard Corp., Chillicothe, Ohio.
[7] A. B. Searle, *loc. cit.*, p. 245.
[8] "Standard Method for Slaking Test," *Jour. Amer. Ceram. Soc.*, 11 [6] 448 (1928).

III. Laboratory Results

(1) Plastic Properties

With additions of Plasticade there was a marked improvement in the plastic properties of both the de-aired and nonde-aired clays, less tendency for dragging of the corners of the column, less swelling of the column after issuing from the die, and sharper edges after cutting.

By means of a plasticimeter,[9] the plasticity of two clays, de-aired and nonde-aired, and with and without plasticade, was determined. These results are shown in Table I.

TABLE I

RELATIVE PLASTICITY

Addition Plasticade (%)	Nonde-aired values	De-aired values
	Virginia shale	
0.00	0.0074	0.0143
0.125	.0107	.0170
0.25	.0142	.0278
0.50	.0101	.0248
1.00	.0093	.0184
	Ohio sagger clay	
0.00	0.0134	0.0230
0.125	.0163	.0262
0.25	.0181	.0273
0.50	.0161	.0246
1.00	.0145	.0235

Additions of more than 0.25% tended to decrease the relative plasticity.

(2) Dry Properties

The data of Table II show that, in general, de-airing reduced slightly the water of plasticity, pore water, and calculated linear shrinkage (calculated from the volume shrinkage) and increased materially the strength of the specimen.

Additions of Plasticade up to and including 0.25% materially reduced the water of plasticity, pore water, and linear shrinkage. Additions of more than 0.25% Plasticade were less effective, indicating that probably at some point near 0.25% the action was changing from flocculation toward deflocculation.

As the amount of additions of Plasticade are increased, the dry strength is greatly increased. The strength of the nonde-aired samples with 0.125% Plasticade, in nearly every case, is equal to or greater than the de-aired samples without Plasticade.

The closer fit of the particles of the clays, due

[9] J. W. Whittemore, "Mechanical Method for the Measurement of the Plasticity of Clays and Mixtures of Clays," *ibid.*, 18, [11] 352–57 (1935).

TABLE II

MOIST AND DRY PROPERTIES (average of five samples)

Additions of Plasticade (%)	Water of plasticity (%)		Pore water (%)		Calculated linear drying shrinkage (%)		Transverse dry strength (lb./sq. in.)	
	Nonde-aired	De-aired	Nonde-aired	De-aired	Nonde-aired	De-aired	Nonde-aired	De-aired
				Virginia shale				
0.0	29.81	29.19	19.18	19.39	6.11	6.30	146	215
0.125	27.19	27.52	18.72	19.31	5.32	5.33	245	257
0.25	27.42	26.46	18.13	18.10	5.41	5.50	263	273
0.50	26.34	25.22	17.16	16.57	5.46	5.75	286	288
1.00	24.85	24.28	15.67	16.15	5.99	5.46	314	399
				Alabama refractory clay (grogged)				
0.0	18.68	19.30	13.82	15.66	3.04	2.84	231	268
0.125		18.46		14.40	2.72	2.62	260	278
0.25	18.35	18.08	14.52	14.64	2.39	2.21	285	290
0.50	19.23	19.34	14.47	15.15	2.97	2.68	295	298
1.00	19.87	18.70	14.30	15.51	3.52		310	337
				Ohio sagger clay				
0.0	27.62	27.98	14.44	16.40	8.64	7.92	215	557
0.125	25.30	28.84	14.12	15.33	7.67	7.36	425	656
0.25	25.21	24.80	14.05	15.80	7.62	6.56	470	641
0.50	27.21	22.85	14.10	15.64	9.02	4.62	545	751
1.00	27.78	25.04	13.51	16.05	9.84	6.19	525	751
				Ohio sewer-pipe clay				
0.0	18.90	18.44	10.88	10.60	5.95	5.79	305	404
0.125	17.94	18.04	9.58	10.07	5.67	5.90	483	793
0.25	14.25	15.29	8.47	10.54	4.18	3.40	541	783
0.50	15.30	14.02	10.21	8.54	3.56	2.72	541	935
1.00	16.82	13.68	10.89	9.91	4.11	4.10	284	893

TABLE III

FIRED PROPERTIES (average of five samples)

Plasticade additions (%)	Calculated linear firing shrinkage (%)		Absorption (%)		Transverse strength (lb./sq. in.)	
	Nonde-aired	De-aired	Nonde-aired	De-aired	Nonde-aired	De-aired
			Virginia shale (fired at 1850°F)			
0.00	1.81	1.88	18.23	15.91	1260	1785
0.125	1.69	1.75	17.82	14.49	1333	2415
0.25	1.10	1.26	16.17	13.33	1444	2431
0.50	0.82	1.26	15.26	15.61	1575	2474
1.00	1.51	0.72	15.47	14.58	2126	2273
			Alabama refractory clay (grogged) (fired at 2000°F)			
0.00	2.14	1.67	18.88	17.26	619	950
0.125	1.32	0.95	17.94	16.45	672	1050
0.25	1.12	1.39	16.54	15.50	735	1076
0.50	1.59	1.64	17.15	14.52	597	914
1.00	1.49	1.67	17.62	15.62	531	893
			Ohio sagger clay (fired at 2000°F)			
0.00	2.33	1.85	18.00	15.44	2608	2783
0.125	2.17	1.68	16.78	15.32	2919	3497
0.25	1.88	2.65	16.26	15.45	2960	3738
0.50	1.99	2.45	16.10	14.29	3029	3103
1.00	2.37		15.62	12.65	3491	2756
			Ohio sewer-pipe clay (fired at 2000°F)			
0.00	2.17	1.24	10.70	10.79	2573	3019
0.125	2.13	0.68	10.21	10.49	2835	3780
0.25	1.63	0.71	8.50	8.07	3066	4762
0.50	1.46		8.55	8.74	3192	3098
1.00	1.29	1.32	9.11	10.67	2468	3213

to the flocculating and agglomerating action of the Plasticade, gives a decrease in the size and number of voids and a subsequent reduction in the pore water and shrinkage and an increase in the strength.

(3) Fired Properties

In general, the fired linear shrinkage of both the de-aired and nonde-aired specimens decreases with the additions of Plasticade up to and including 0.25%. Further additions of Plasticade

tend to cause an increase in the shrinkage in most cases.

The absorption of all of the materials studied was lowered considerably by additions of Plasticade and by de-airing. The absorption of the de-aired samples was lowered considerably by additions of Plasticade. In general the absorption of the nonde-aired clays with additions of 0.25% Plasticade is equal to or less than the absorption of the untreated de-aired clays.

The fired strength of all of the clays with additions of Plasticade and with de-airing was greatly increased up to additions of approximately 0.50%.

IV. Plant Experiments

(1) Procedure

The plant experiments were made at a brick plant, a tile plant using de-airing, and a tile plant not using de-airing.

Because additions of 0.125% Plasticade gave the greatest benefit in the laboratory tests on the clays from these three plants, it was decided to try this percentage addition in making the plant experiments.

This amount of Plasticade was added to each pit car of clay being dumped into the bin feeding the grinding equipment. It was added at this stage of the manufacture to obtain as thorough mixing with the clay as possible.

The column of clay containing Plasticade, as it issued from the die, was marked so that the ware could be easily identified after drying and firing.

(2) Plastic Properties

The plasticity of the clay (at the three plants) was increased by the addition of Plasticade. This was easily noted by "feel" and the general appearance of the extruded column. As the column of clay containing Plasticade issued from the die, it was much more firm and free from cracks. In the case of the solid column for the manufacture of brick at plant No. 1, the corners of the column were sharper and the edges of the brick, after cutting, were sharp and firm as compared to the ragged edges of the untreated brick. In the manufacture of tile at plants No. 2 and No. 3, there was less tendency for dragging of the web and corners of the column containing the addition of Plasticade.

(3) Dry Properties

Samples of the ware made from clay with and without additions of Plasticade were tested after drying. The results of these tests are shown in Table IV. A count was made of the number

TABLE IV

DRY COMPRESSIVE STRENGTH

Plasticade addition (%)	Compressive strength (lb./sq. in.) Plant No. 1	Plant No. 2	Plant No. 3
0.00	239	115	65.29
0.125	354	178	95.86

of pieces of ware with and without additions of Plasticade, rejected per car by the setters. These results are shown in Table V.

TABLE V

DRYING LOSS

Plasticade addition (%)	No. of cars set	Average No. of pieces per car rejected	Drier loss (%)
	Plant No. 1		
0.00	25	24	5.0
0.125	22	3	0.3
	Plant No. 2		
0.00	59	24	25.0
0.125	44	5	5.2
	Plant No. 3		
0.00	119	23	38.33
0.125	39	11	19.66

The addition of Plasticade materially increased the dry strength of the specimen (45%, 55%, and 43%, respectively).

The reduction in the drying loss by the use of Plasticade at these plants, calculated on the basis of the percentage drying loss of the untreated specimen was 94%, 79%, and 50%, respectively.

(4) Fired Properties

The batches of ware with and without additions of Plasticade, were set in the same relative position in the kiln. This insured the same firing conditions for both types. On removal of the ware from the kilns, samples were taken of each type from each course of the setting. These samples were tested to determine the effect of the Plasticade on the fired ware. The properties of the ware from the top third, the middle third, and the bottom third of the kiln were averaged separately. These results are shown in Table VI.

The addition of Plasticade increased the fired strength and decreased the absorption of the

ware at all three plants. The average compressive strength was increased 28%, 25%, and 27%, respectively.

The absorption was decreased at plant No. 1 from 10.38 to 7.97%; at plant No. 2 from 7.38 to 6.66%; and at plant No. 3 from 3.83 to 3.17%.

The plant results follow closely the results obtained in the laboratory.

TABLE VI

FIRED PROPERTIES

Plasticade addition (%)	Average compressive strength (lb./sq. in.)				Average absorption (%)			
	Ware from top 3rd of kiln (av.)	Ware from middle 3rd of kiln (av.)	Ware from bottom 3rd of kiln (av.)	Average	Ware from top 3rd of kiln (av.)	Ware from middle 3rd of kiln (av.)	Ware from bottom 3rd of kiln (av.)	Average
				Plant No. 1				
0.00	4754	6259	4966	5326	8.94	9.48	12.71	10.38
0.125	7064	7405	5948	6806	6.46	7.06	10.38	7.97
				Plant No. 2				
0.00	1880	1964	1067	1637	6.58	6.91	8.65	7.38
0.125	2178	2246	1684	2036	6.28	6.51	7.18	6.66
				Plant No. 3				
0.00	821	1043	812	892	2.79	3.54	5.16	3.83
0.125	1296	1184	906	1129	2.57	2.30	4.65	3.17

Because it was difficult to obtain the losses after firing and unloading of the kiln at plants No. 1 and No. 2, no record was made. At plant No. 3 it was possible to obtain an accurate count of these losses which are as follows:

Number of pieces of ware set in kiln	2345	
Without Plasticade		
Set	448	
Approved	356	
Rejected	92	(20.60%)
With Plasticade		
Set	1897	
Approved	1842	
Rejected	55	(2.9%)

This improvement of the ware after firing and the reduction of losses during firing and the subsequent handling are explained by the same reasoning as for the reduction of losses in drying. The coagulation of the clay particles by the action of the Plasticade resulted in a better and closer fit of the particles, thus enabling the formation of ware which could better withstand the strains of forming, drying, firing, and handling.

V. Conclusions

The addition of Plasticade to clays and shales improves the plastic properties. It increases the strength both of dried and fired ware, decreases the water of plasticity, pore water, shrinkage (both dried and fired), and absorption. Because of these changes in the physical properties, the losses in drying, firing, and handling are materially reduced.

The amount of any flocculating agent to be added to a clay to obtain the maximum improvement of the physical properties varies with different clays. It so happened that the three clays studied in the plant experiments of the investigation required 0.125% Plasticade for maximum improvement.

It is noteworthy that the results of the plant experiments follow closely those obtained in the laboratory.

The marked improvement of the physical properties of the ware and the decrease in the losses, by addition of the Plasticade warrants the use of this material at these three plants.

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SOME DRYING PROPERTIES OF CLAYS: I–III

I, Effect of Small Imposed Loads on the Rate of Drying of Some Clays*

By H. G. Schurecht† and C. Major Lampman‡

Abstract

The increased rate of drying caused by low pressures on the ware is a factor in drying which must be recognized particularly with large shapes and in drier car settings of considerable heights. Pressures of the magnitude encountered under these conditions were found to increase the rate of drying as high as 58% in the case of some clays, causing the unloaded portions to have 3.30 times as much water as the loaded portions during certain periods of drying. All clays are effected to a greater or less extent, but it is most prominent in clays of low plasticity.

I. Introduction

The effect of load on drying seems to have escaped the attention of investigators. In fact it has been assumed in the past that, in drying large shapes, it is necesary to cover the upper portions in order to reduce the drying rate to that expected in the lower portions. That this assumption is subject to limitations was noted by the authors in an investigation of the effects of pallet friction on shrinkage. It was found that small imposed loads not only affected the shrinkage but also the rate of drying. This observation led to a detailed investigation of the effects of low pressures on the drying properties of clays. The results will be presented in a series of papers.

In all drying operations, some load is imposed on some of the ware or some parts of the same. Stiff-mud brick, stacked one half of the drier car height, or five high on edge, develop 1 to $1^1/_2$ pounds pressure per square inch on the brick in the bottom course. When dry-press brick or incompletely dried brick are set directly in the kiln, the load is much higher. Hollow building block are usually stacked the entire height of the drier car, and it has frequently been noted that the bottom pieces crack. The strains caused by the drying effect and the accompanying retardation of shrinkage sometimes make it necessary to protect the bottom block by putting a course of half blocks underneath. In order to counteract blistering and warpage, terra cotta building blocks are often stacked two, three, or four high. In all large pieces, such as hand-pressed terra cotta, sanitary ware, sewer pipe, chemical stoneware, and large refractory shapes, the bottom portions of the ware carry considerable load, and as a result differential drying conditions prevail in different parts of the ware.

Although not correlated with the differential drying phenomenon, desirable effects of one kind and another have been noted in drying ware under load. In the case of drying blocks, 2 by 8 by 16 inches stacked three high, the warpage results were as follows:

Warpage in 16 inches	(in.)
Top block	0.035
Middle block	0.012
Bottom block	0.019

Because the top blocks were covered with cardboard, the only difference was that the lower blocks were dried under slight pressure. It is apparent, therefore, that the effect of load was to make the blocks about twice as straight as they would otherwise be. It is apparent, therefore, that the effect of load in drying is an important factor in the rate of drying and in correlated effects and that the subject is worthy of investigation.

The object of the investigation is to compare representative clays as to their drying characteristics as effected by loads of various degrees, comparable with loads encountered in industrial practice, and to determine the extent of the effects on the general quality of the ware.

II. Experimental Methods

The clays were molded into bars, $1^1/_8$ by $1^1/_8$ by $6^1/_2$ inches, and were set between smooth fir plywood boards, as shown in Fig. 1. These were weighted to produce pressures of 0.017, 0.135, 0.475, 0.952, 1.270, and 1.56 pounds per square inch, respectively, on the bars. Great care was

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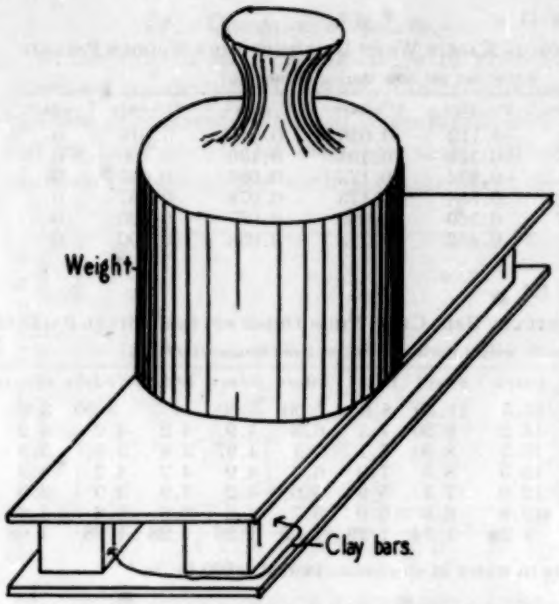

FIG. 1.—Method of loading clay bars during drying.

used to maintain the same water content for each clay. As much water as possible was added to the clay without causing it to become sticky when tested by pressing a metal spatula against it. In subsequent batches with this clay, the same water content was maintained fairly constant by weighing the dry clay and by adding the predetermined amount of water by volume.

The bars were weighed immediately after molding and also each day while drying at room temperature; they were finally dried at 110°C.

The percentage water was calculated in terms of plastic weight, and the results represent the average of at least two tests in each case.

The materials studied were Kentucky ball clay, Binghamton shale, and Georgia kaolin.

III. Results

The effect of low pressures on the rate of drying of Georgia kaolin is shown in Tables I and II and in Figs. 2 and 3. It is evident that a pressure of 1.560 pounds per square inch increases the rate of drying to a marked extent during the first three days, and in some cases it is 58 % greater than the unloaded specimen. As a result of this differential

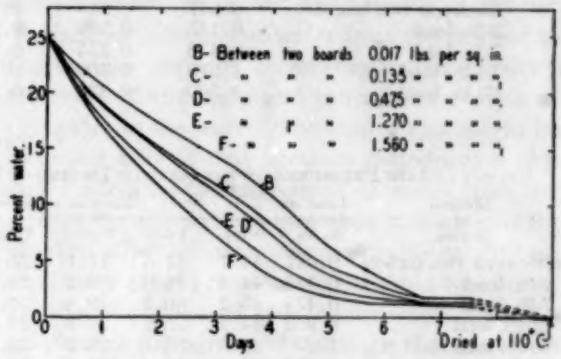

FIG. 2.—Effect of low pressures on the rate of drying of Georgia kaolin.

drying, at the end of $3^5/_8$ days the unloaded specimens contain 2.44 times as much water as the loaded specimens and at $4^5/_8$ days this ratio becomes 3.30; it then gradually diminishes to zero (see Table I and Fig. 6).

The results with Kentucky ball clay are given in Table III and Fig. 4. Here again low pressures on

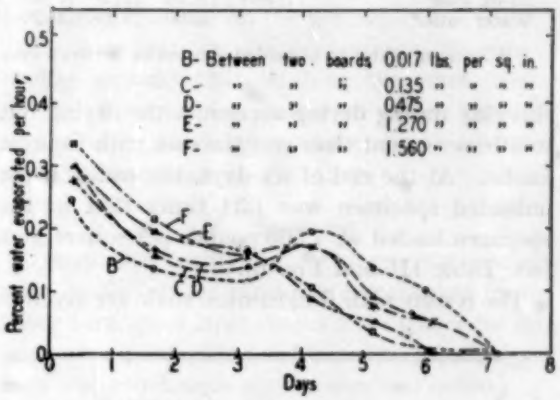

FIG. 3—Effect of low pressures on the rate of drying of Georgia kaolin.

TABLE I

EFFECT OF LOW PRESSURES ON RATE OF DRYING OF GEORGIA KAOLIN WHEN DRIED BETWEEN WOODEN PALLETS

Method of drying	Load on specimens (lb./in.²)	Water in terms of plastic weight during drying at room temperature (%)							
		0 day	$^5/_8$ day	$2^5/_8$ days	$3^5/_8$ days	$4^5/_8$ days	$5^5/_8$ days	$6^5/_8$ days	$7^5/_8$ days
Between two boards	0.017	25.1	21.69	15.04	12.24	7.57	4.29	1.89	1.89
2-lb. load	0.135	25.1	20.37	12.96	9.73	5.56	3.24	1.86	1.86
7-lb. load	0.475	25.1	20.37	12.59	8.79	4.63	2.77	1.39	1.39
16-lb. load	1.270	25.1	19.82	10.36	6.30	3.15	1.80	1.80	1.80
23-lb. load	1.560	25.1	19.18	8.68	5.02	2.29	1.37	1.37	1.37
Water ratio*		1.00	1.13	1.74	2.44	3.30	3.12	1.38	1.38

* Ratio of water in unloaded specimens between two boards to water in specimens loaded 1.560 lb./in.²

TABLE II

EFFECT OF LOW PRESSURES ON THE RATE OF DRYING OF GEORGIA KAOLIN WHEN DRIED BETWEEN WOODEN PALLETS

Method of drying	Load on specimens (lb./in.²)	Water lost per hour during drying (%)						
		1/16 day	1 1/8 days	3 1/8 days	4 1/8 days	5 1/8 days	6 1/8 days	7 1/8 days
Not covered or loaded	0.000	0.555	0.252	0.112	0.039	0.019	0.019	0
Between two boards	0.017	0.248	0.138	0.116	0.194	0.136	0.100	0
2-lb. load	0.135	0.308	0.154	0.134	0.173	0.096	0.057	0
7-lb. load	0.475	0.275	0.162	0.158	0.173	0.078	0.057	0
16-lb. load	1.270	0.300	0.197	0.169	0.089	0.057	0.000	0
23-lb. load	1.560	0.334	0.210	0.152	0.113	0.038	0.000	0

TABLE III

EFFECT OF LOW PRESSURES ON THE RATE OF DRYING OF KENTUCKY BALL CLAY WHEN DRIED BETWEEN STEEL PALLETS

Method of drying	Load on specimens (lb./in.²)	Water in terms of plastic weight during drying at room temperatures (%)											
		0 day	1 day	2 days	3 days	5 days	6 days	7 days	8 days	9 days	10 days	13 days	14 days
Between two pallets	0.017	44.7	37.5	31.1	27.2	16.5	11.50	8.9	7.50	5.30	4.6	3.90	3.90
2-lb. load	0.135	44.4	36.6	30.2	24.7	14.2	9.60	7.3	6.3	4.9	4.2	4.2	4.2
7-lb. load	0.475	45.2	36.2	29.1	24.1	13.5	8.90	7.1	6.1	4.97	3.8	3.8	3.8
12-lb. load	0.952	44.1	35.7	28.6	23.8	13.3	8.5	7.0	6.3	4.9	4.2	4.2	4.2
16-lb. load	1.270	43.5	35.5	28.2	23.2	12.0	7.3	5.9	5.6	4.2	3.9	3.9	3.9
23-lb. load	1.560	44.4	36.4	28.6	24.2	12.9	8.6	6.9	5.7	4.3	3.6	3.6	3.6
Water ratio*		1.01	1.03	1.09	1.12	1.28	1.34	1.29	1.32	1.23	1.28	1.08	1.08

* Ratio of water in unloaded specimens between two boards to water in specimens loaded 1.560 lb./in.²

TABLE IV

EFFECT OF LOW PRESSURES ON THE RATE OF DRYING OF BINGHAMTON SHALE WHEN DRIED BETWEEN WOODEN PALLETS

Method of drying	Load on specimens (lb./in.²)	Water in terms of plastic weight during drying at room temperatures (%)											
		0 day	1 day	2 days	3 days	5 days	6 days	7 days	8 days	9 days	10 days	13 days	20 days
Between two pallets	0.017	15.70	12.75	9.60	8.32	2.61	1.79	1.79	1.79	1.29	1.29	1.29	1.29
2-lb. load	0.135	15.70	12.40	8.53	6.09	2.02	1.62	1.46	1.46	1.22	1.22	1.22	1.22
7-lb. load	0.475	15.70	11.95	7.75	5.37	2.22	1.59	1.59	1.59	1.43	1.43	1.43	1.43
12-lb. load	0.952	15.70	12.10	7.90	5.38	2.20	1.82	1.82	1.82	1.32	1.32	1.32	1.32
16-lb. load	1.270	15.70	12.22	8.20	5.60	1.58	1.41	1.41	1.41	0.99	0.99	0.99	0.99
23-lb. load	1.560	15.70	11.80	7.65	4.96	1.65	1.24	1.24	1.24	1.08	1.08	1.08	1.08
Water ratio*		1.00	1.08	1.26	1.67	1.58	1.44	1.44	1.44	1.20	1.20	1.20	1.20

* Ratio of water in unloaded specimens between two boards to water in specimens loaded 1.560 lb./in.²

this clay during drying accelerate the drying but to a lesser extent than was the case with Georgia kaolin. At the end of six days, the water in the unloaded specimen was 1.34 times that in the specimen loaded at 1.560 pounds per square inch (see Table III and Fig. 6).

The results with Binghamton shale are given in Table IV and Fig. 5. Here again low pressures increased the rate of drying. This effect was greater with this clay than with Kentucky ball clay but was not as much as that obtained with Georgia kaolin. At the end of three days, the water content in the unloaded specimen was 1.67 times that in the specimens loaded at 1.560 pounds per square inch (see Table IV and Fig. 6).

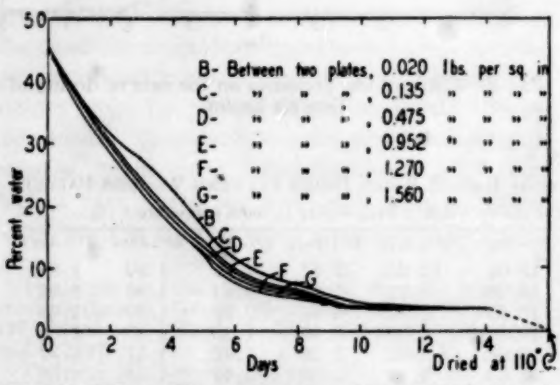

FIG. 4.—Effect of low pressures on the rate of drying of Kentucky ball clay.

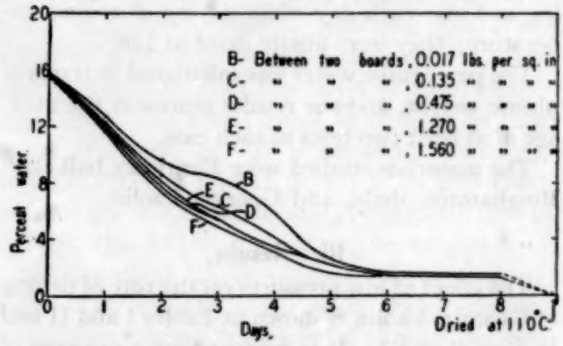

FIG. 5.—Effect of low pressures on the rate of drying of Binghamton shale.

IV. Discussion of Results

In the case of each clay, increase in pressure increased the drying rate. Under the conditions of these experiments (at room temperature without air turbulence), the effect was most marked between the second and sixth days, the effect disappearing, of course, as the percentage of water in the body approached zero. When the percentage of water in the body sinks below 1 % the effect of pressure is small but still apparent.

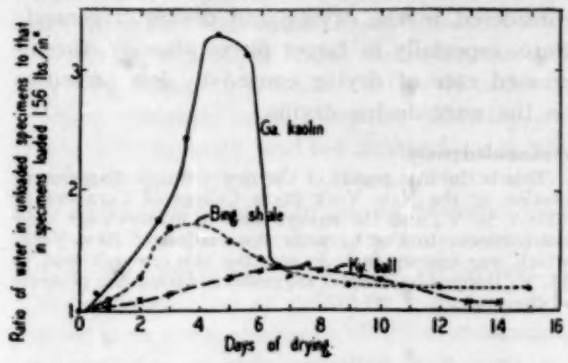

FIG. 6.—Relative water content in clays under varying pressures during drying.

Evidently the effect of pressure is confined to shrinkage water and most of the pore water and does not greatly affect the last traces of pore water and hygroscopic water in clays. The bulk of the water in a stiff-mud body, however, is chiefly affected by the pressure. Inasmuch as this water is involved in the shrinkage characteristics of the clay, pressure application to the ware is directly connected with shrinkage and the accompanying characteristics of the clay.

Of the clays studied, those less plastic showed the greatest pressure effect. With Georgia kaolin, which is moderately plastic, the effect was much greater than with the highly plastic Kentucky ball clay. The Binghamton shale, which is of intermediate plasticity, showed an effect lying between the other two clays. Further work is contemplated to bring out more fully the relationship between plasticity and pressure effect.

Any theory that might be offered to explain the effect of pressure on drying would likely involve the factor of diffusion of water to the surface. Fundamentally, the rate of drying depends on the rate of evaporation of water at the surface of the ware and the rate of capillary diffusion of water from the interior to the surface of the ware. The rate of evaporation at the surface depends on the vapor pressure of the water in the ware, the vapor pressure of the water-vapor in the atmosphere, and the movement of the air. These in turn depend on temperature, humidity, the angle of incidence of the air on the ware, and the velocity of the air. The rate of diffusion of water from the interior to the surface depends largely upon the capillary structure of the body and the surface tension of the water in the ware. The theory that might be proposed here is that pressure introduces a new factor affecting the movement of water from the interior to the surface and that it is an entirely physical effect. Under ordinary drying conditions, capillarity effects may be accentuated by shrinkage effects which tend to force the water hydraulically out of the pores and it may be that the effect of pressure is to increase this hydraulic effect.

The practice of molding and drying the bottoms of large vessels and letting them partially dry before building up the sides seems to be justified when one considers that the center of the bottom is practically under no pressure, while the sides are under considerable load and would dry faster. If the center bottom were not allowed to dry before building up the sides, the slower drying of the center bottom may cause severe strains and cracks on the outside of the bottom which drys faster because of the load on the bottom.

The fact that the pressures increase the rate of drying suggests that stacking the ware during drying as a means of increasing drying capacity and reducing handling costs may prove advantageous in many cases.

V. Summary

The rates of drying of three representative clays were studied under pressures encountered in the lower portions of large shapes and in drier car settings of considerable heights. The principal results and conclusions are summarized below.

(1) Low pressures on clays or clay products during drying increase their rate of drying.

(2) This increase in speed of drying varies with different clays and is less for extremely plastic clays than it is for short clays.

(3) With Georgia kaolin, the rate of drying was increased as much as 58% by applying a load of 1.56 pounds per square inch during drying.

(4) As a result of the increased rate of drying caused by pressure, specimens not loaded contained 1.34 to 3.30 times as much water as the loaded specimen at certain periods of drying.

(5) Stacking pieces produces straighter ware and tends to overcome blistering. It also reduces handling in many cases. The chief objection to stacking has been the belief that it slowed up drying too much because it covered up the lower pieces. This work indicates that the retardation of drying, due to being covered, is partly compensated for by the imposed pressure on the same which speeds up the drying.

(6) The fundamental factor which heretofore has been recognized or used to control drying is the diffusion of the water from the interior of clay products to the surface, which is in turn controlled by the capillary structure of the body and the surface tension of the water. The rate of evaporation of the water from the surface has been also recognized as another major factor, and this is controlled by the temperature, humidity, and velocity of air. This work indicates that all these controlling factors may be kept constant, but there may be a large variation in drying behavior, due to varying pressures which are present in different portions of large pieces. It is apparent, therefore, that a new fundamental drying factor must be considered in the drying and design of ceramic ware, especially in larger pieces, namely, the increased rate of drying caused by low pressures on the ware during drying.

Acknowledgment

This is the first report of the new Ceramic Experiment Station at the New York State College of Ceramics at Alfred, N. Y., and the writers wish to acknowledge their indebtedness to the Ceramic Association of New York, which was instrumental in starting this research, and to M. E. Holmes for helpful suggestions during the progress of the work.

I, Effect of Small Imposed Loads on Shrinkage Behavior and Plastic Properties of Some Clays*

By H. G. Schurecht and C. Major Lampman

Abstract

Marked differences in shrinkage behavior and plastic deformations are caused by pressures commonly present in large shapes and in ware stacked during the drying period. Strains resulting from these variations may explain excessive cracking frequently encountered in large shapes and in the lower pieces in drier car settings. Plastic clays tested under the conditions of this test showed two yield values instead of one as was the case with tests made with the Bingham plastometer. The tensile strength of a clay during drying was found to be a linear function of its water content.

I. Introduction

Retaining the structure possessed directly after molding is of fundamental importance in producing ceramic ware of the highest structural quality. To do this, the ware should not be deformed in the plastic condition; it must dry at a uniform rate; the shrinkage rate should be the same throughout the piece; and the ware must be permitted to contract freely in drying.

In plant operations, it is comparatively easy to make small pieces, but with larger shapes cracking too frequently develops in drying, firing, or in service. Some large pieces can be successfully made only by permitting partial drying of the lower portions before building them up, as is the case in the molding of glass pots and chemical stoneware. Where large pieces are pressed in plaster molds, as in hand-pressed terra cotta, the conditions are especially severe and cracking can be reduced only by using extremely plastic bond clays with high strength. In this case the lower portions are not permitted to dry before building up the piece, but they are turned on a pallet while still plastic throughout. Any conjecture to explain the greater amount of cracking in such pieces would have to account for more strains in the larger pieces than in the smaller ones at some period in its plant history. This work shows that the greater amount of strains in larger pieces can be explained by the increased deformation and differential drying effects in these pieces resulting from the greater variation in pressures in different portions of large shapes. The factors which cause these drying strains to vary for different clays explain why some clays are more suitable for making large shapes than others, and a closer study of the properties of bond clays should materially reduce cracking and other structural defects.

Where ware is stacked to considerable heights on drier cars, similar phenomena have been no-

* See * footnote, p. 266.

ticed. With hollow building block, stacked three high, it has been observed that the lower pieces crack more than those on top, especially if clays with low plasticity and strength are used or if the die adjustment becomes slightly out of balance from a shifting of the cores or wear of the auger blades. Too frequently this cracking first appears after firing and thus causes heavy losses.

When high strength is not essential, stacking may be justified to a limited extent in order to produce straighter ware, overcome blistering, increase drier capacity, and reduce handling as was previously pointed out.[1] When structure and high strength are important as, for example, with paving brick, the practice of stacking in drying might cause the brick to fail in the rattler test.

For a large class of products, such as hand-pressed terra cotta, glass pots, chemical stoneware, sanitary ware, electric porcelain, and large refractory shapes, a sound structure and high strength are not only desirable but are necessary A study of oversize ware is also important where uniformity of size is required. With ware that is to be ground to definite dimension, such as terra cotta, excessive oversize may make grinding too costly.

It has been shown in previous work[2] that low pressures may greatly increase the rate of drying. The work has been extended in this investigation to study the effects of low pressures on new properties of bodies, namely, the plastic deformation, freedom of contraction, and rate of shrinkage, with special reference to their tendency to cause strains. In the course of the investigation, new data on the plasticity of clays were collected.

II. Materials and Methods

Five clays representative of different types and one talc were selected for these experiments and were as follows: (1) Kentucky ball clay, (2) Georgia kaolin, (3) Roseton surface clay, (4) Syracuse plastic clay, (5) Binghamton shale, and (6) New York talc.

The method of testing in this case was similar to that described in a previous report.[3] Shrinkage measurements were made on both sides of the $1^1/_8$- by $1^1/_8$- by $6^1/_2$-inch bars. The water content was maintained approximately constant throughout these tests for each clay after having determined the amount necessary for normal working consistency. To determine the plastic elongation, the distances between the shrinkage marks were measured directly after applying the load, and the percentage plastic extension was calculated as follows:

$$P = \frac{L_2 - L_1}{L_1} \times 100 \qquad (1)$$

P = plastic extension (%)
L_1 = original distance between shrinkage marks (in.)
L_2 = distance between shrinkage marks after applying loads (in.)

The specimens were then allowed to dry between smooth fir plywood boards and steel pallets, weighted to produce pressures of 0.017, 0.135, 0.475, 0.952, 1.270, and 1.56 pounds per square inch, respectively, on the plastic clay bars.

The distances between the shrinkage marks were measured on the dry bars, and from these data the total oversize caused by the combined effects of plastic extension and drying under load were calculated as follows:

$$O = \frac{L_3 - L_1}{L_1} \times 100 \qquad (2)$$

O = oversize (%)
L_3 = dry length between shrinkage marks (in.)
L_1 = original lengths between shrinkage marks before applying load (in.)

The oversize was also expressed in terms of the total drying shrinkage without pressure to obtain more comparable data for the different clays as follows:

$$RO = \frac{O}{S} \times 100 \qquad (3)$$

RO = relative oversize of clay
O = oversize (%)
S = drying shrinkage for each clay (%)

The relation between water content and shrinkage of clays was studied by weighing and measuring the shrinkage of Kentucky ball-clay bars when dried under varying pressures at frequent time intervals.

The tensile strength of the same clay was also measured during different stages of drying, which permitted a study of the relations between tensile strength and rate of shrinkage of clays during drying.

III. Discussion of Results

(1) Plastic Extension of Clays

The results of the tests on the plastic extension of the clays are shown in Tables I and II and in Figs. 1 and 2.

[1] See Part I, Section IV, p. 269.
[2] See Part I, Section III, p. 267.
[3] See p. 266.

TABLE I

EFFECT OF LOADS ON PLASTIC EXTENSION OF SOME CLAYS AND A TALC

Method of drying	Load on specimens (lb./in.²)	Elongation of plastic clay bars caused by applying load between pallets (%)					
		Ky. ball clay	Ga. kaolin	Roseton clay	Syracuse clay	Binghampton shale	N. Y. talc
Between two plates	0.017	0	0	0	0	0	0
2 lb.	0.135	0	0	0.78	0	0.52	1.04
7 lb.	0.475	0	0	1.56	0.78	1.04	1.56
12 lb.	0.952	0	0	2.08	1.30	1.43	2.08
16 lb.	1.270	0	0	2.60	1.44	1.70	2.34
23 lb.	1.560	0.52	0.32	2.86	2.86	1.83	2.86
35 lb.	2.360	0.78	0.52				
50 lb.	3.380	2.08	2.50				

TABLE II

PROPERTIES OF SOME CLAYS AND A TALC WHEN PRESSURE IS APPLIED IN PLASTIC STATE

Properties*	Yield points		Flow of clay under load							
			First large elongation			Intermediate small elongation			Second large elongation	
	First a (lb./in.²)	Second i (lb./in.²)	b (%)	c (lb./in.²)	$\frac{b}{c}$	d (%)	e (lb./in.²)	$\frac{d}{e}$	f (lb./in.²)	$\frac{dg}{dh}$
Ky. ball clay	1.27	2.45	0.42	0.25	1.68	0.30	0.90	0.33	0.85	1.23
Ga. kaolin	1.27	2.50	0.30	0.25	1.20	0.25	0.95	0.26	0.60	2.48
Roseton clay	0.017	1.05	1.00	0.10	10.00	1.50	1.00	1.50	2.00	1.65
Syracuse clay	0.135	1.50	1.50	0.36	4.17	0.41	0.90	0.46	1.50	18.0
Binghamton shale	0.017		0.95	0.30	3.17					
Talc	0.170	1.40	1.20	0.10	12.00	1.40	1.20	1.17	2.45	2.40

* See Fig. 2 for an interpretation of these properties.

When low pressures are applied to the plastic clay bars they remain constant in size until, when a definite pressure is reached, they commence to deform. This pressure is indicated as a in Fig. 2 and is closely related to the yield value as determined with the Bingham plastometer.[4] The fact that the curve does not pass through the origin shows that, with these clays under the conditions of this test, a certain definite pressure must be exceeded before the substance will flow. This definite initial friction value that has to be exceeded distinguishes the plastic from the viscous

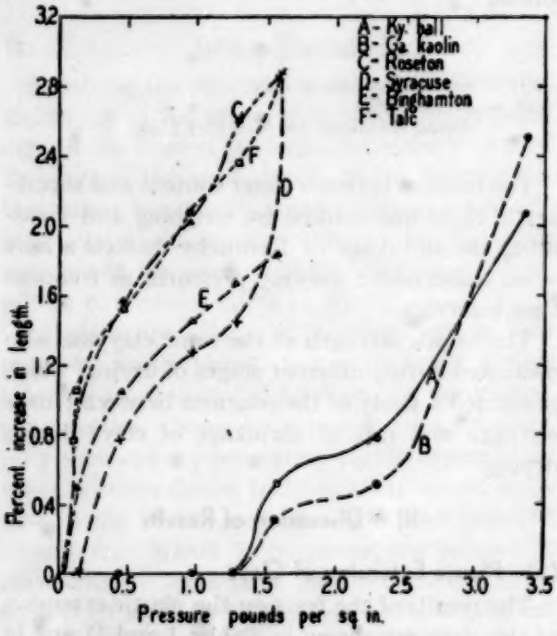

FIG. 1.—Effect of pressure on the plastic increase in length of clay bars.

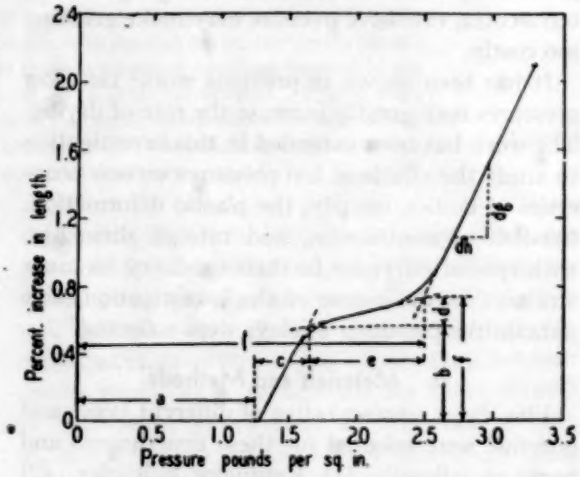

FIG. 2.—Effect of pressure on the plastic increase in length of a clay.

[4] F. P. Hall, "Methods of Measuring the Plasticity of Clays," *Bur. Stand. Tech. Paper*, No. 234, 22 pp. (March 21, 1923).

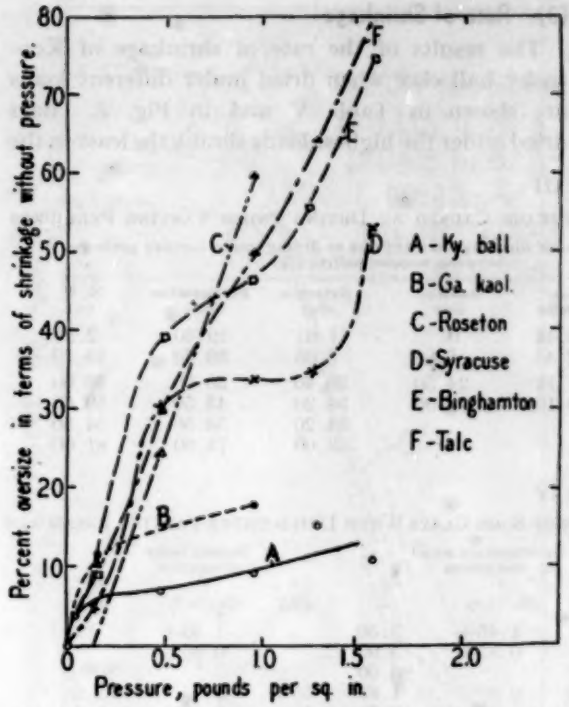
Percent. oversize in terms of shrinkage without pressure.
Pressure, pounds per sq. in.
A - Ky. ball
B - Ga. kaol.
C - Roseton
D - Syracuse
E - Binghamton
F - Talc

FIG. 3.—Effect of pressure during drying on the dry size of some clays.

state. It should be high for the most plastic clays as well as for those most capable of withstanding pressures during drying.

After the clay starts to deform, the total elongation continues at a uniform rate with an increase in pressure until a definite load is reached; it then changes to a much slower rate and again to a rapid rate at a higher pressure. Just what causes this flattening of the curve remains to be determined, but it may be closely related to the water in the clay and the packing of the clay particles. For example, this first elongation may be caused by a packing or readjustment of clay grains under the influence of pressure, and the second extension may develop initially when the force is sufficient to exceed a definite frictional value necessary to cause the packed clay particles to flow. This flattening of the curve differs from the flow curve as determined with a Bingham plastometer which does not develop this intermediate flattening.

This first elongation is represented by *b* in Fig. 2, and for clays capable of supporting loads during drying it should be as low as possible. The second elongation is represented by *d* and must also be small. This flattening of the curve is evidently closely related to the plasticity of the clay as it is not so evident with those possessing low plasticity. For clays best able to carry loads during drying, *e* and *i* should be high and *d* must be small; *a* should be as large as possible, while *c*, $\frac{b}{c}$, *f*, $\frac{dg}{dh}$, and $\frac{d}{e}$ must be small.

(2) Dry Dimensions of Clays

The results of tests on the effect of pressure on the dry dimensions of these clays are shown in Tables III and IV and Figs. 3 and 4.

These data represent the combined results of plastic deformation and shrinkage effects, and the curves, as a result, differ from those for plastic deformation. It is evident that the oversize increases as soon as zero pressure is exceeded, differing in this respect from the plastic extension curves, where the size of the bars remained the same until a considerable pressure was reached. The retardation of shrinkage of the bars at low pressures continued until a definite load was reached, when it slowed up (see *b* in Fig. 4). It is apparent from these data that plastic clays do not have sufficient strength to shrink freely when loaded and that a certain strength must be developed before they can shrink without restraint.

When additional pressures are applied during

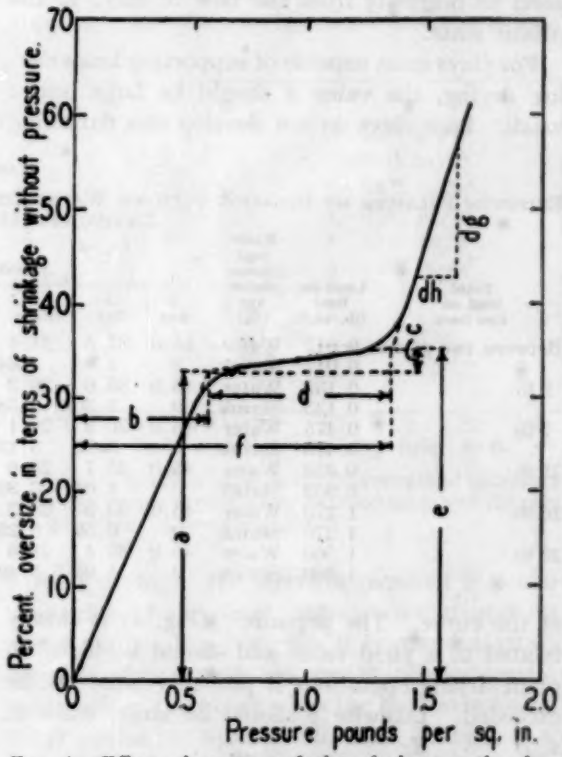

FIG. 4.—Effect of pressure during drying on the dry size of a clay.

drying the oversize is small for quite a range of pressures (see *c*, Fig 4). This flattening of the curve seems to be more marked for the dry bars than it is for the plastic bars. The flattening of the curve and the subsequent increase in oversize seem to originate from the flow of clays in the plastic state.

For clays most capable of supporting loads during drying, the value *d* should be large and *c* small. Poor clays do not develop this flattening of the curve. The pressure *f* (Fig. 4) is closely related to a yield value and should be high; in plant drying operations it probably must not be exceeded. Likewise *b* should be large, while *a*, $\frac{a}{b}$, $\frac{c}{d}$, *e*, and $\frac{dg}{dh}$ must be small.

(3) Rate of Shrinkage

The results of the rate of shrinkage of Kentucky ball clay when dried under different loads are shown in Table V and in Fig. 5. Bars dried under the highest loads shrank the least in the early stages of drying. This retardation is overcome only when the tensile strength of the clay reaches a certain value necessary to overcome the restraining effects of the imposed loads.

To determine the magnitude of the tensile strength required to overcome restraining effects of shrinkage, the tensile strength of Kentucky ball clay was determined at frequent periods during drying, and the results are shown in Table VI and Fig. 6. The tensile strength is a linear function of its water content until it drops to about

TABLE III

PERCENTAGE OVERSIZE OF CLAY IN TERMS OF THEIR SHRINKAGE CAUSED BY DRYING UNDER VARYING PRESSURES

	Load on specimens (lb./in.²)	Oversize in terms of shrinkage of clays due to drying under varying pressures between wooden pallets (%)					
		Ky. ball clay	Ga. kaolin	Roseton clay	Syracuse clay	Binghamton shale	N. Y. talc
Between two pallets	0.017	4.36	3.44	0	1.01	19.30	2.38
2 lb.	0.135		12.45	−5.80	5.05	39.20	10.10
7 lb.	0.475	7.30	1.11	24.50	30.40	26.00	30.00
12 lb.	0.952	9.35	18.10	60.00	34.20	45.50	50.00
16 lb.	1.270	15.10			34.20	54.50	54.50
23 lb.	1.560	10.40			53.00	74.00	81.00

TABLE IV

COMBINED EFFECTS OF SHRINKAGE AND PLASTIC DEFORMATION OF SOME CLAYS WHEN DRIED UNDER VARYING PRESSURES

	First large elongation			Intermediate small elongation				Second large elongation	
Properties*	*a* (%)	*b* (lb./in.²)	$\frac{a}{b}$	*c* (%)	*d* (lb./in.²)	$\frac{c}{d}$	*e* (%)	*f* (lb./in.²)	$\frac{dg}{dh}$
Ky. ball clay	5	0.05	10		1.45+	3.50		1.50+	
Ga. kaolin	12	0.10	12		0.85+	5.90		0.95+	
Roseton clay			80			80.00			80.0
Syracuse clay	32	0.60	53	1.5	0.80	1.87	35.0	1.35	82.5
Binghamton shale	39.5	0.43	91	9.5	0.70	13.70	50.0	1.15	82.5
Talc	29.0	0.50	59	25.0	0.55	45.50	55.0	1.15	82.5

* See Fig. 4 for an interpretation of these properties.

TABLE V

EFFECT OF PRESSURE ON RELATION BETWEEN WATER CONTENT AND SHRINKAGE OF KENTUCKY BALL CLAY DURING DRYING BETWEEN STEEL PALLETS

Total load on two bars	Load on bars (lb./in.²)	Water and linear shrinkage (%)	Water in terms of dry weight and shrinkage in terms of plastic length during drying (%)										
			0 day	1 day	2 days	3 days	5 days	6 days	7 days	8 days	9 days	10 days	14 days
Between two plates	0.017	Water	45.0	37.5	31.1	27.2	16.5	11.5	8.9	7.5	5.3	4.6	3.90
"	0.017	Shrink.	0	1.83	3.64	4.95	6.64	6.76	6.90	6.90	6.90	6.90	6.90
2 lb.	0.135	Water	45.0	36.6	30.2	24.7	14.2	9.6	7.3	6.3	4.9	4.2	4.20
"	0.135	Shrink.	0	1.30	3.38	4.95	5.73	5.74	5.99	5.99	5.99	5.99	5.99
7 lb.	0.475	Water	45.0	36.2	29.1	24.1	13.5	8.9	7.1	6.1	4.97	3.8	3.80
"	0.475	Shrink.	0	0.78	3.13	4.81	5.73	5.73	5.73	5.73	5.73	5.73	5.73
12 lb.	0.952	Water	45.0	35.7	28.6	23.8	13.3	8.5	7.0	6.3	4.9	4.2	4.2
"	0.952	Shrink.	0	1.04	3.39	5.20	5.87	5.87	5.99	5.99	5.99	5.99	5.99
16 lb.	1.270	Water	45.0	35.5	28.2	23.2	12.0	7.3	5.9	5.6	4.2	3.9	3.9
"	1.270	Shrink.	0	0.52	3.25	4.62	5.48	5.48	5.59	5.59	5.59	5.59	5.59
23 lb.	1.560	Water	45.0	36.4	28.6	24.2	12.9	8.6	6.9	5.7	4.3	3.6	3.6
"	1.560	Shrink.	0	1.03	3.49	5.05	6.08	5.56	5.96	5.96	5.96	5.96	5.96

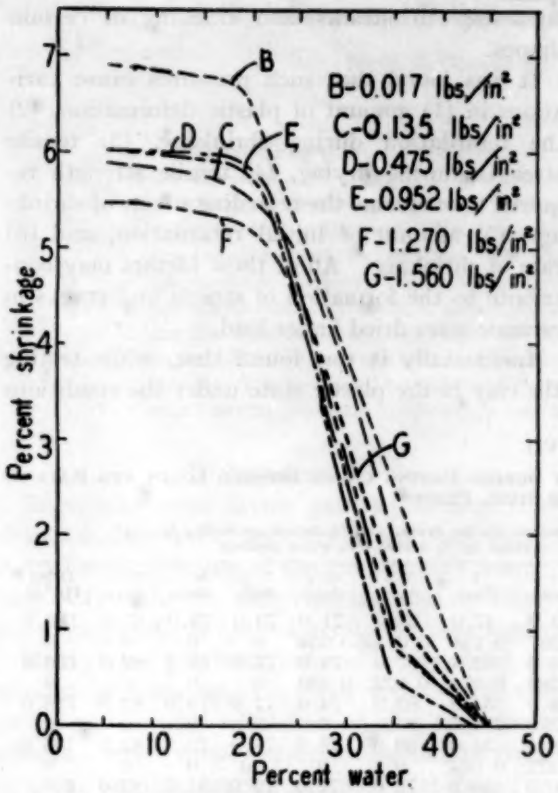

FIG. 5.—Effect of low pressures on the relation between shrinkage and water contents of Kentucky ball clay (steel pallets).

4% when it rapidly rises. The relation between the strength and water content may be represented by the following formula for water contents above 4%.

$S = K(W_1 - W_2)$

S = tensile strength (lb./in.²)
W_1 = water in clay when it changes from plastic to viscous condition corresponding to point where it crosses horizontal axis (%)
W_2 = water in clay during drying (%)
K = constant characteristic of each clay

For Kentucky ball clay, K was found to be 1.88 and W_1 was estimated to be about 48%. Water-of-plasticity tests, as commonly conducted on clays, are somewhat illusive because they vary considerably for different investigators, whereas the value, W_1, can be determined with much more accuracy.

TABLE VI

TENSILE STRENGTH OF KENTUCKY BALL CLAY DURING DRYING

	Days of drying						Dried at 110°C
	0	0.65	1.67	1.98	2.64	4.65	
Water (%)	45.6	33.2	13.1	8.4	4.1	1.6	0
Tensile strength	3.0	25.0	64.7	74.5	63.5	80.0	136.7

The results of a study of the relationship between tensile strength and rate of shrinkage of Kentucky ball clay under varying loads are shown in Table VII and Fig. 7.

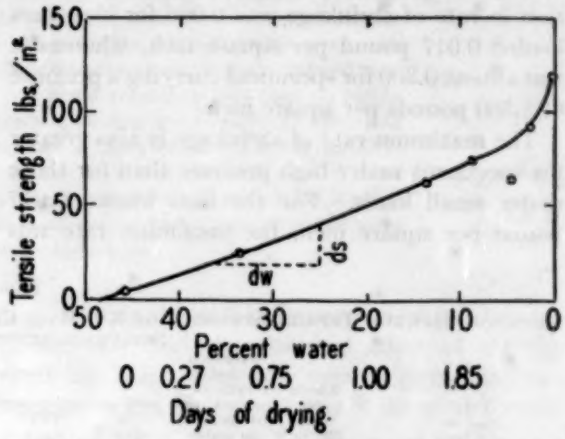

FIG. 6.—Relation between water content and tensile strength of Kentucky ball clay.

The rate of shrinkage per unit decrease in water content is restrained until a definite tensile strength is reached; the shrinkage rate then reaches a maximum and gradually decreases upon further drying. The strength required for maximum rate of shrinkage increases for greater imposed loads. For example, it required a tensile strength of 24 pounds per square inch for a maximum rate of shrinkage when the bars were loaded 0.017 pound per square inch, but a strength of 45 pounds per square inch was required before the

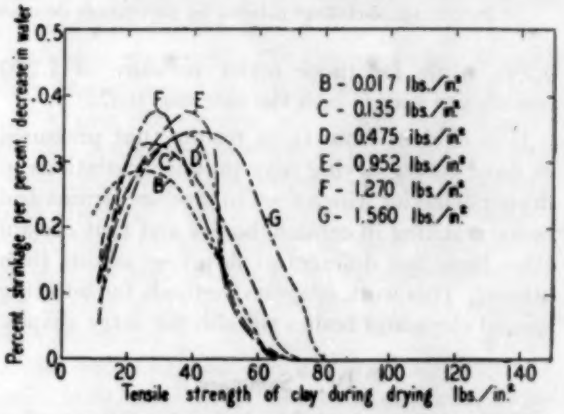
B - 0.017 lbs./in.²
C - 0.135 lbs./in.²
D - 0.475 lbs./in.²
E - 0.952 lbs./in.²
F - 1.270 lbs./in.²
G - 1.560 lbs./in.²
Percent shrinkage per percent decrease in water
Tensile strength of clay during drying lbs./in.²

FIG. 7.—Relation between tensile strength of Kentucky ball clay during drying under imposed loads and the rate of shrinkage (between steel plates).

maximum rate of shrinkage was developed with bars loaded 1.560 pounds per square inch.

The initial retardation of shrinkage was also lower for smaller loads and higher for large pressures (see Fig. 7). For example, the initial retardation in rate of shrinkage was 0.066 for clay bars loaded 0.017 pound per square inch, whereas it was almost 0.300 for specimens carrying a pressure of 1.560 pounds per square inch.

The maximum rate of shrinkage is also greater for specimens under high pressure than for those under small loads. For the bars loaded 0.017 pound per square inch, the maximum rate was 0.280, while for those under pressure of 1.270 pounds per square inch the rate was 0.375.

It is evident from these results that pressures in ware during drying may produce variations in drying behavior which tend to produce strains and hence cracking in ceramic bodies and that certain clays have less differential shrinkage effects than others. This work suggests methods for selecting special clays and bodies suitable for large shapes.

TABLE VII

RELATION BETWEEN TENSILE STRENGTH OF KY. BALL CLAY DURING DRYING UNDER IMPOSED LOADS AND RATE OF SHRINKAGE BETWEEN STEEL PLATES

Total load on two bars	Loads on bars (lb./in.²)	Strength and ratio of shrinkage to decrease in water	Tensile strength during drying and % shrinkage during drying divided by % decrease in water content									
			½ day	1½ days	2½ days	4 days	5½ days	6½ days	7½ days	8½ days	9½ days	Dried 110° C
Between two plates	0.017	Strength	10.0	22.0	33.0	47.0	63.0	71.0	74.0	78.0	81.0	136.7
"	0.017	Ratio*	0.244	0.284	0.267	0.158	0.024	0.054	0	0	0	0
2 lb.	0.135	Strength	12.0	24.0	36.0	62.0	67.0	74.0	77.0	79.0	82.0	136.0
"	0.135	Ratio	0.151	0.336	0.286	0.074	0.022	0.103	0	0	0	0
7 lb.	0.475	Strength	12.0	26.0	38.0	54.0	69.0	74.0	77.0	79.0	82.0	136.0
"	0.475	Ratio	0.089	0.330	0.336	0.087	0	0	0	0	0	0
12 lb.	0.975	Strength	12.0	27.0	38.0	54.0	69.0	75.0	78.0	79.0	82.0	136.0
"	0.975	Ratio	0.112	0.332	0.377	0.063	0	0	0	0	0	0
16 lb.	1.270	Strength	12.0	28.0	40.0	58.0	72.0	77.0	79.0	81.0	83.0	136.0
"	1.270	Ratio	0.055	0.375	0.274	0.077	0	0	0	0	0	0
23 lb.	1.560	Strength	12.0	26.0	38.0	54.0	70.0	76.0	77.0	80.0	83.0	136.0
"	1.560	Ratio	0.120	0.315	0.354	0.091	0.121	0.235	0	0	0	0

* Percentage shrinkage divided by percentage decrease in water during drying.

IV. Summary

Tests were conducted to determine the variation in the drying behavior of clays due to low pressures commonly present in large shapes and in ware stacked for drying and to study their relationship to strains and cracking of certain shapes.

It was found that such pressures cause variations in (1) amount of plastic deformation, (2) the retardation during shrinkage, (3) tensile strength during drying, (4) tensile strength required to overcome the retarding effects of shrinkage, (5) amount of initial retardation, and (6) rate of shrinkage. All of these factors may contribute to the formation of strains and cracks in ceramic ware dried under load.

Incidentally it was found that, while testing the clay in the plastic state under the conditions of these tests, clays showed (1) an initial yield value or pressure when the clay commenced to flow, (2) an initial flow of the clay, (3) a slowing up of the flow for a range of pressures, (4) a second yield value, and (5) a second flow of clay at higher pressures.

The tensile strength of Kentucky ball clay during drying was found to be a linear function of its water content until the water content dropped to about 4%. By extrapolation, the water content of which this clay changes from a plastic to a viscous state was determined.

Acknowledgment

The writers wish to acknowledge their indebtedness to M. E. Holmes for his courteous and suggestive interest in this work.

III, Influence of Pallets on the Quality of Clay Products*

By H. G. Schurecht and C. Major Lampman

Abstract

The retarding effects of surfaces of drying pallets to shrinkage of ceramic products are known to exert important influences on the quality of some ware. In retarding the shrinkage, strains are set up in the body which decrease the strength and in some cases cause cracking of the ware. Wooden surfaces, when tested along the grain, proved to be less injurious than steel or glass. The effect was much greater on lean than on highly plastic clays. Reducing the friction and adherence of the clay to steel pallets by covering them with sand, cardboard, or grease produced marked improvements in strength. Drying the ware under imposed loads also lowered the quality of the ware, but in some cases this effect was not as great as that produced by substituting steel for wooden pallets. The use of drying pallets with as low frictional resistance as possible will solve many drying problems in the heavy clay products industries.

I. Introduction

Friction between drying pallets and large clay shapes during drying may strain and crack them. Actual measurements of the comparative magnitude of this effect on different clays and on different drying surfaces has not heretofore been made.

Heavy clay products are commonly dried on wooden or metal pallets. For terra cotta, the pallets are covered with sand or grog to prevent adhesion, which would reduce strains and the tendency to produce tearing cracks. Cardboard is used for the same purpose and is also placed between the faces of blocks which are stacked for drying. Grease is sometimes used under large shapes to reduce the rubbing of the ware on the pallet during shrinkage.

In pressing glass pots, the surface of the pallets is often covered with 4 inches of grog about $^3/_4$ inch in diameter. Spare edges which are chipped off after firing are frequently pressed on large pieces of terra cotta to support the ware in drying. These spare edges are placed in direct contact with the pallet and receive most of the strains due to pallet friction. The drying pallets are also often tilted to assist the ware in creeping over the pallet during shrinkage with a minimum amount of friction.

Since the pressure obtained in the lower portions of large shapes and in the bottom courses of high drier car settings tends to intensify this friction, tests were conducted with varying pressures similar in magnitude to those encountered in practice.

These differences in frictional resistance of different pallet surfaces were measured. It soon developed that other factors in addition to friction, such as the suction between steel pallets and plastic clay and the chemical effect of certain materials like grease, also exerted important influences on the drying behavior of the clays tested.

* Received May 28, 1937.

II. Experimental Methods

The clays were molded into bars, $1^1/_8$ by $1^1/_8$ by $6^1/_2$ inches, which were set between different drying pallets by the method described in Part I of this series.[1]

The drying surfaces used were (1) smooth fir plywood boards, (2) glass pallets, (3) steel pallets, (4) steel pallets covered with grease, (5) steel pallets covered with sand, and (6) steel pallets covered with cardboard.

Weights were applied to the top pallets to produce static pressures of 0.17, 0.135, 0.475, 0.952, 1.270, and 1.56 pounds per square inch, respectively. Although the effect of pallet friction was exaggerated in these experiments by having pallets both above and below the clay bars, comparable results were obtained, and the data procured indicate to a degree what might be expected to occur in that portion of the ware in direct contact with the pallet.

The shrinkage retardation was expressed as oversize in terms of the shrinkage obtained without load by the method described in Part II.[2] Dry cross-breaking strengths of the bars were determined by the usual method using a 5-inch span and the results given represent the average of at least six tests.

III. Discussion of Results

The results of tests of the influence of pallet

[1] See Part I, Section II, p. 266.
[2] See Part II, Section II, p. 271.

TABLE I

EFFECT OF DIFFERENT DRYING SURFACES ON DRY SIZE OF TWO CLAYS DRIED UNDER IMPOSED LOADS

Drying method	Load on specimens (lb./in.²)	Percentage oversize in terms of shrinkage of clays due to different drying surfaces when dried under imposed loads: Roseton clay — Between wooden pallets	Roseton clay — Between glass plates	Syracuse clay — Between wooden boards	Syracuse clay — Between glass plates	Kentucky ball clay — Between wooden boards	Kentucky ball clay — Between glass plates	Kentucky ball clay — Between steel plates	Kentucky ball clay — Steel covered with grease	Kentucky ball clay — Steel covered with sand	Kentucky ball clay — Steel covered with cardboard
Not covered, or loaded	0.000	0	0	0	0	0	0	0	0	0	0
Between two plates	0.017	0.00	12.30	6.95	4.25*	5.50	−3.14	−5.50†	14.70	6.58	0.98
2 lb.	0.135	−17.60	36.60*	6.55	19.10*	11.10	3.62	−5.35†	10.25	5.69	7.35
7 lb.	0.475	− 4.40	78.00*	26.20*	29.70*	7.95	8.00	10.90†	10.25	11.20	8.65
12 lb.	0.952	17.60	*	28.50*	42.60*	10.20	18.70*	13.10†	15.10*	18.70	8.50
16 lb.	1.270	23.60	78.50*	32.50*	46.00*	16.10	21.40*	22.00†	24.10*	15.00	16.20
23 lb.	1.560	62.00	97.00*	48.10*	60.50*	12.50	27.60*	21.80†	18.00*	16.80	16.30
35 lb.	2.370							25.20†	35.80*	25.20	23.40*
50 lb.	3.380							40.00†			

* Cracked.

† Bars covered with rust from steel plates but not cracked.

TABLE II

EFFECT OF PALLET FRICTION ON DRY STRENGTHS OF KENTUCKY BALL CLAY AND GEORGIA KAOLIN

Drying method	Load on specimens (lb./in.²)	Modulus of rupture (lb./in.²): Kentucky ball clay dried between pallets — Wooden	Kentucky ball clay dried between pallets — Glass	Kentucky ball clay dried between pallets — Steel	Georgia kaolin dried between pallets — Wooden	Georgia kaolin dried between pallets — Glass	Georgia kaolin dried between pallets — Steel
Between two pallets	0.017	267.0	229.7	193.7	249.0	210.0	196.0
2 lb.	0.135	263.2	193.0	192.0	245.0	212.0	163.0
7 lb.	0.475	253.0	206.7	214.2	243.0	226.0	210.0
12 lb.	0.952	250.6	160.0	184.5	261.0	204.0	176.5
16 lb.	1.270	242.8	160.0	179.7	207.0	203.0	
23 lb.	1.560	216.0	194.7	179.0	202.0	191.0	227.0

TABLE III

EFFECT OF PALLET FRICTION ON DRY STRENGTHS OF SYRACUSE AND HUDSON RIVER CLAYS

Drying method	Load (lb./in.²)	Modulus of rupture (lb./in.²): Syracuse clay dried between pallets — Wooden	Syracuse clay dried between pallets — Glass	Hudson river clay dried between pallets — Wooden	Hudson river clay dried between pallets — Glass
Between two pallets	0.017	143.5	150.8	110.0	0
2 lb.	0.135	142.0	82.3	236.0	25.1
7 lb.	0.475	145.1	30.0	228.0	0
12 lb.	0.952	145.0	0	146.0	49
16 lb.	1.270	140.7	15.2	92.5	0
23 lb.	1.560	133.3	0	102.0	143

TABLE IV

EFFECT OF CARDBOARD, SAND, AND GREASE SURFACES ON DRYING PALLETS ON DRY STRENGTH OF KENTUCKY BALL CLAY

Drying method	Load on specimens (lb./in.²)	Modulus of rupture (lb./in.²): Between steel pallets covered with cardboard	Between steel pallets covered with sand	Between steel pallets covered with greases
Between two plates	0.017	217.5	136.3	257.0
2 lb.	0.135	151.5	214.3	227.0
7 lb.	0.475	155.0	139.5	325.0
12 lb.	0.952	134.0	257.4	195.0
16 lb.	1.270	200.0	175.3	222.5*
23 lb.	1.560	188.0	104.7	196.0*
35 lb.	2.360	176.0*	217.7	227.0*
Average		174.0	177.8	235.6

* Cracked.

friction on the shrinkage of clays are shown in Table I and in Figs. 1 to 4.

From Fig. 1, it is evident that Roseton clay shrinks much less when dried between glass plates than when dried between wooden boards, indicating that glass retards the shrinkage more than wood. This effect is more marked when the specimens are dried under low imposed load than without a load. It is probable that a suction is created between the plastic clay bars and glass and that this causes the plastic clay to adhere to the glass pallets during the early stages of drying. The more porous structure of the wooden pallets prevents suction and permits the clay bars to shrink more freely over this surface.

Similar results were obtained with Syracuse clay but to a lesser extent (see Fig. 2). This clay is more plastic than Roseton clay, which may account for its ability to overcome the retarding effects of the drying surfaces.

The effects of glass, steel, and wooden drying surfaces on the shrinkage of Kentucky ball clay are shown in Fig. 3. Glass retards the shrinkage more than steel, while steel retards it more than wood. It is again obvious that clays of high plasticity like Kentucky ball clay are affected to a

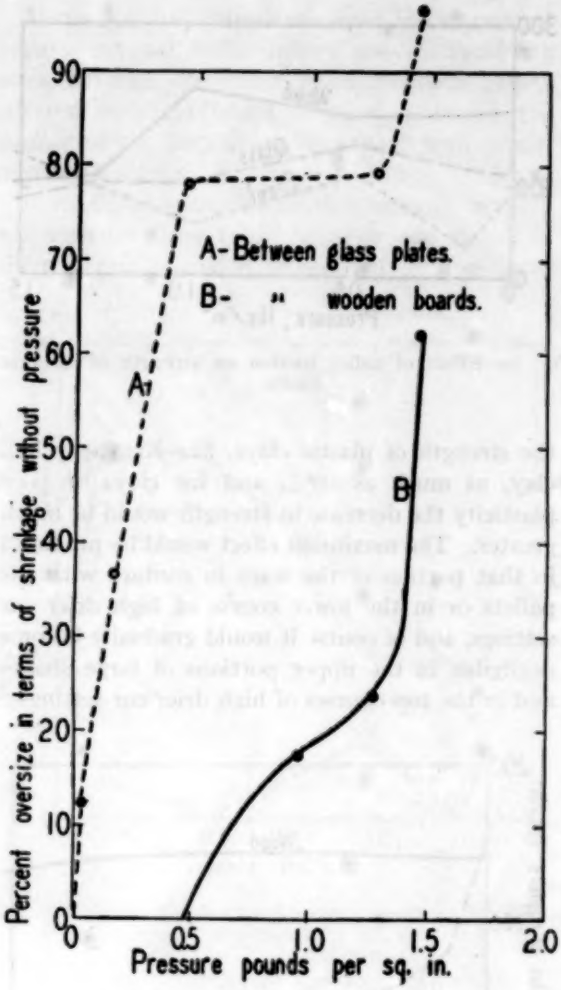

FIG. 1.—Effect of different drying pallets on dry size of Roseton clay dried under imposed loads.

lesser degree than those of low plasticity. The cohesive forces evidently are greater in the finer grained plastic clays than in the granular lean clays.

The reduction in rubbing between the pallet and the clay during drying, by covering the steel plates with grease, sand, or cardboard, is shown by the shrinkage effects on the clay bars dried in contact with these surfaces (see Fig. 4). All of these surface coverings reduced the frictional resistance of the pallets as is shown by the greater shrinkage of the pieces dried on such surfaces. When grease was used, the surface of the bars turned from gray to blue and developed surface cracks; thus it is probable that the grease exerted an effect on the

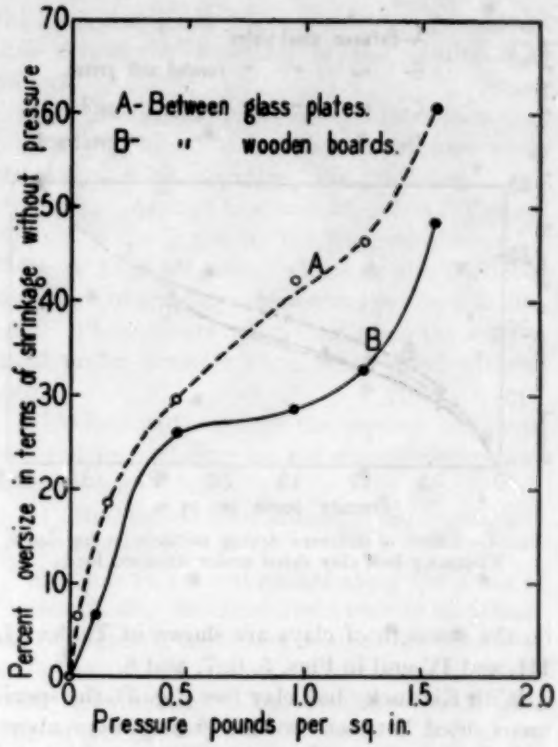

FIG. 2.—Effect of different drying pallets on dry size of Syracuse clay dried under imposed loads.

clay which caused it to crack along the surface in contact with the grease.[3]

The results of the effects of frictional resistance

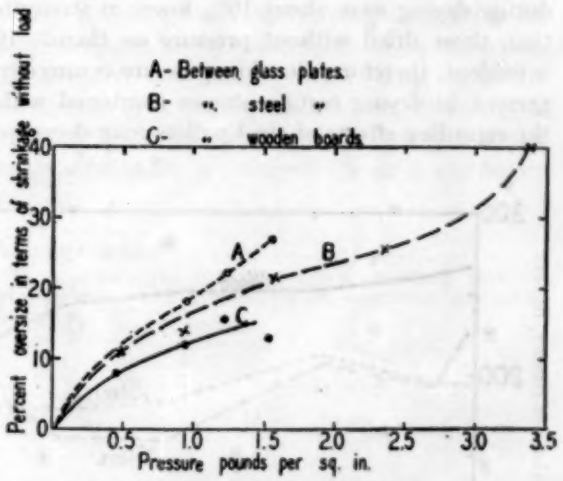

FIG. 3.—Effect of different drying pallets on dry size of Kentucky ball clay dried under imposed loads.

[3] The grease used in this case was Socony Lubricant Chassilube No. 0.

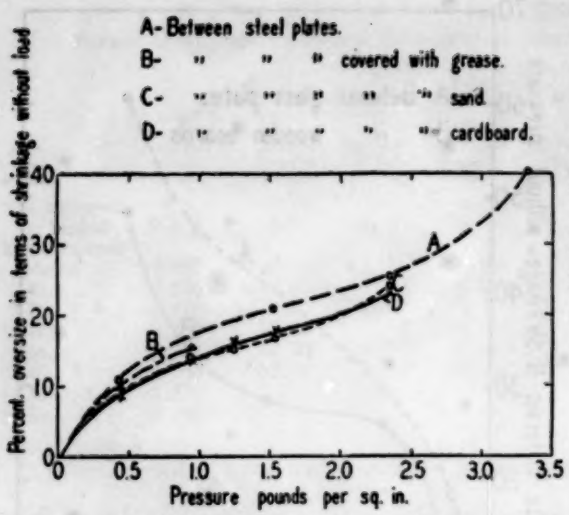
A- Between steel plates.
B- " " " covered with grease.
C- " " " " " sand.
D- " " " " " cardboard.
Percent. oversize in terms of shrinkage without load
Pressure pounds per sq. in.

FIG. 4.—Effect of different drying surfaces on dry size of Kentucky ball clay dried under imposed loads.

on the strength of clays are shown in Tables II, III, and IV and in Figs. 5, 6, 7, and 8.

With Kentucky ball clay (see Fig. 5), the specimens dried between wooden pallets were about 20% stronger than those dried between steel and glass pallets. It is apparent that specimens dried between wood were strained less than those dried between steel or glass. The bars dried in contact with steel were slightly stronger than those dried between glass plates, but they were decidedly weaker than those dried in contact with wood.

Specimens loaded 1.56 pounds per square inch during drying were about 19% lower in strength than those dried without pressure on them. It is evident, therefore, that low pressure commonly present in drying certain shapes combined with the retarding effects of steel pallets may decrease

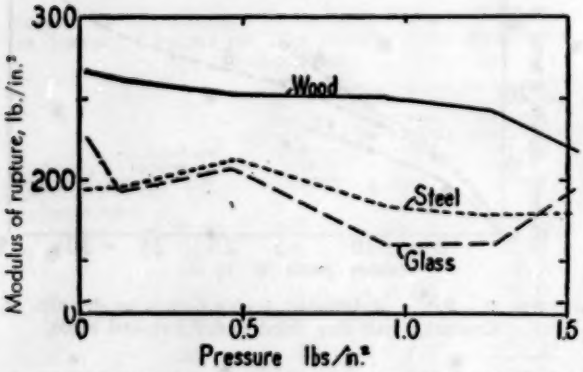

FIG. 5.—Effect of pallet friction on strength of Kentucky ball clay.

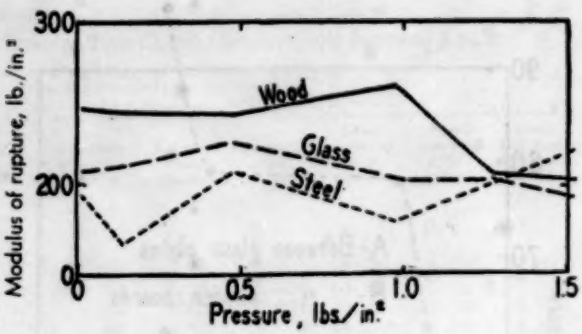

FIG. 6.—Effect of pallet friction on strength of Georgia kaolin.

the strength of plastic clays, like Kentucky ball clay, as much as 40%, and for clays of poor plasticity the decrease in strength would be much greater. The maximum effect would be produced in that portion of the ware in contact with the pallets or in the lower course of high drier car settings, and of course it would gradually become negligible in the upper portions of large shapes and in the top courses of high drier car settings.

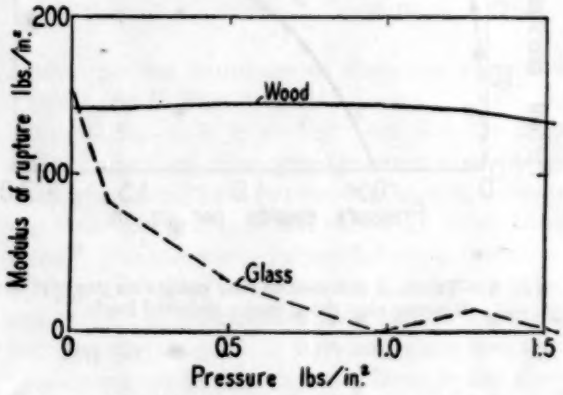

FIG. 7.—Effect of pallet friction on strength of Syracuse clay.

With Georgia kaolin (Fig. 6), the specimens dried between wooden pallets were stronger than those dried between glass or steel pallets. Georgia kaolin is affected less than Kentucky ball clay probably because it has a more slippery surface in the plastic state.

With Syracuse plastic clay, the strength of the specimens dried between wood was also decidedly higher than that of those dried between glass plates (Fig. 7). With Hudson River clay, small pressures apparently increased the strength while higher pressures reduced it (Fig. 8).

Kentucky ball-clay bars, dried between steel pallets covered with grease, proved decidedly stronger than specimens dried between pallets covered with cardboard or sand, although the surface of the bars dried in contact with grease developed cracks.

It must be remembered that smooth firwood was used for these tests; other woods may give different results, and it is planned to investigate other woods as well as rough wooden surfaces. The maximum shrinkage took place along the grain of the wood in these tests; different results probably would be obtained across the grain of the wood.

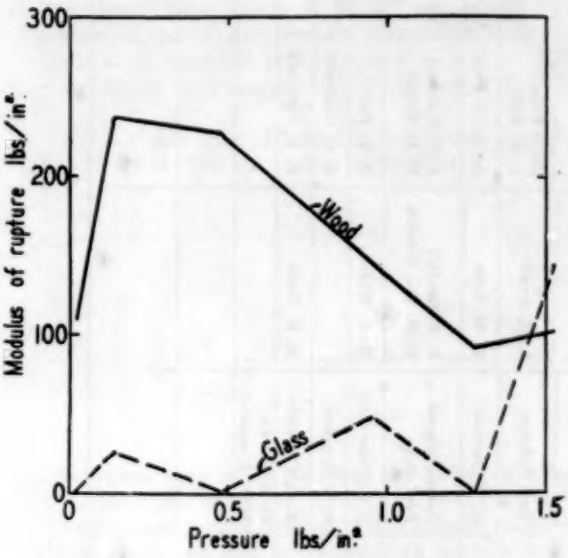

FIG. 8.—Effect of pallet friction on strength of Hudson River clay.

IV. Summary

The influence of different drying surfaces on the shrinkage and strength of clays was studied. The results apply chiefly to those portions of large shapes in contact with the pallets and in the lower courses of drier car settings of considerable height. A summary of the results is as follows:

(1) The resistance of surfaces on which clay products are dried to creeping of the ware while shrinking may decrease the shrinkage and strength of the ware to a marked extent. This reduction is much greater for lean clays than for those of high plasticity, although the frictional resistance of the clays themselves is also a factor.

(2) These effects are greater when the ware is dried under pressure than when dried without load.

(3) Glass surfaces offer the greatest resistance to shrinkage and decrease the strength more than other drying surfaces.

(4) Steel pallets have proved to be only slightly better than glass.

(5) Smooth firwood pallets along the grain of the wood offer the least resistance to shrinkage and decrease the dry strength much less than steel and glass pallets. Tests across the grain of the wood were not made but probably would give different results.

(6) Covering steel pallets with sand, grog, cardboard, or grease proved beneficial insofar as strength of the clay bars is concerned, but in the case of grease, excessive surface cracking developed. Where the pallets were covered with sand, grog, or cardboard, practically no cracking occurred.

It is apparent that more attention should be paid to reducing the frictional resistance of drying pallet surfaces; and this will lower losses materially and improve the quality of the ware. The development of a drying pallet with as nearly a frictionless surface as possible is suggested and would solve many problems in the drying of heavy products.

Acknowledgments

In conclusion the writers wish to acknowledge their indebtedness to M. E. Holmes for his suggestive interest in this work.

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August, 1937

16—8

Abrasives

Abrasives used in the polishing and buffing of metals. R. S. Leather. *Metal Ind.* [N. Y.], **34**, 304 (1936).—The following materials, in order of their hardness, toughness, and sharpness, are used as cutting-down and color-buffing abrasives: fused alumina, emery, unfused alumina, chromium oxide, tripoli, pumice, amorphous or soft silica, lime, iron oxide, and putty powders. Each has its own particular field of application. The heavy metal-oxide abrasives of iron and chromium are made artificially. The tendency has been toward artificial abrasives more exactly controlled. Six references. See *Ceram. Abs.*, **16** [6] 165 (1937). H.K.R.

Methods of finishing metallographic specimens. Henry R. Power. *Metal Cleaning & Finishing*, **9** [5] 429–32 (1937).—Two forms of abrasive most commonly used for lapping samples after smoothing and prior to polishing are finely graded loose polishing grains and fixed grains in the form of wheels, disks, rubbing stones, and coated abrasive belts. When properly selected and used, loose grain involves less trouble than fixed grain. For "smoothing" before lapping or polishing is started, wheels or belts are used. Gradings of abrasives for these and four finishing methods are listed. E.J.V.

Suitable oils for machining light metal alloys on automatic machine tools. K. Beuerlein. *Aluminium*, **19** [3] 175–76 (1937).—Light metals are worked either with cooling oils mixed with water or with pure lubricating oils. Petroleum should not be used, as it evaporates too easily and impairs breathing. The ratio of oil to water is generally 1:15 to 1:25. A special centrifugal cleaner for oil to remove even the smallest metallic particles is described. M.H.

PATENTS

Abrasive article. C. E. Wooddell and J. F. Barnes (Carborundum Co.). Can. 364,155, Feb. 16, 1937 (Nov. 1, 1934). H. C. Martin and F. A. Upper (Carborundum Co.). Can. 364,294, Feb. 23, 1937 (April 25, 1935). G.M.H.

Abrasive grain coating method. R. C. Benner and R. L. Melton (Carborundum Co.). Can. 363,173, Jan. 5, 1937 (Oct. 15, 1934). G.M.H.

Abrasive products and method of making. J. N. Kuzmick and Jerome Kuzmick (Raybestos-Manhattan, Inc.). U. S. 2,083,719, June 15, 1937 (April 3, 1936). An abrasive article consists of abrasive granules bonded together with a synthetic resin and lead oxide, the lead oxide being intimately intermingled and reacted with the synthetic resin bond and being so combined therewith as to form toughened and hardened coatings over the abrasive granules.

Abrasive saw tooth. Fred Bley (Carborundum Co.). Can. 363,174, Jan. 5, 1937 (April 23, 1935). G.M.H.

Abrasive wheel manufacture. Baalis Sanford (Norton Co.). Can. 363,237, Jan. 5, 1937 (Feb. 3, 1936). G.M.H.

Carriage mounting for grinding machines. H. E. Balsiger and C. L. Ott (Landis Tool Co.). U. S. 2,083,682, June 15, 1937 (Nov. 25, 1931; renewed Nov. 12, 1936).

Ceramic bonded abrasive article. Lowell H. Milligan and David Armitage (Norton Co.). Can. 363,848, Feb. 2, 1937 (Oct. 22, 1934). G.M.H.

Crystalline abrasive and method of production. Charles R. Walker (Abrasive Products, Inc.). Can. 363,869, Feb. 2, 1937 (Nov. 18, 1935). G.M.H.

Cup grinder. W. P. Leshure. U. S. 2,082,404, June 1, 1937 (Sept. 1, 1936).

Diamond wheel dresser. F. F. Gilmore. U. S. 2,081,808, May 25, 1937 (Sept. 25, 1936).

Form grinding apparatus. H. J. Griffing and C. G. Flygare (Norton Co.). U. S. 2,082,734, June 1, 1937 (June 26, 1936).

Grinding and abrading mechanism. Norton Co. Brit. 465,683, May 26, 1937 (April 3, 1935).

Grinding machine. Clement Booth (Cincinnati Grinders, Inc.). U. S. 2,083,115, June 8, 1937 (May 20, 1927; Dec. 24, 1934). W. H. Wood (Norton Co.). U. S. 2,082,728, June 1, 1937 (June 6, 1936). W. H. Wood and C. G. Flygare (Norton Co.). U. S. 2,082,727, June 1, 1937 (April 29, 1936).

Grinding or polishing device. Lloyd Burkhalter (Ray E. Falkinburg and Maynard L. Davis). U. S. 2,083,685, June 15, 1937 (July 27, 1936).

Grinding wheel. W. L. Howe (Norton Co.). Can. 363,236, Jan. 5, 1937 (Dec. 26, 1935). Baalis Sanford (Norton Co.). Can. 364,052, Feb. 9, 1937 (Feb. 3, 1936). D. E. Webster (Norton Co.). Can. 363,724, Jan. 26, 1937 (March 18, 1936). G.M.H.

Grinding wheel and method of making. D. E. Webster (Norton Co.). U. S. 2,081,843, May 25, 1937 (Dec. 14, 1935). A method of making a grinding wheel comprises placing in a mold a quantity of abrasive grains and a plastic organic bond, placing against the bottom plate and top plate of the mold a sheet of soft compressible substance, placing the mold in a press, pressing, and indurating, whereby there is formed a wheel in which abrasive grains project outwardly from the body thereof on the side faces of the wheel.

Honing apparatus. H. S. Indge (Norton Co.). U. S. 2,082,737, June 1, 1937 (Feb. 4, 1936).

Honing tool. J. R. Rose, J. C. Cox, and F. H. Maas (Wagner Electric Corp.). U. S. 2,083,400, June 8, 1937 (Feb. 15, 1935).

Knife grinder. W. E. Jones and J. D. Taylor (Taylor-Colquitt Co.). U. S. 2,083,069, June 8, 1937 (Jan. 2, 1936).

Lapping machine. H. S. Indge (Norton Co.). U. S. 2,084,279, June 15, 1937 (May 14, 1936).

Machine for producing and re-sharpening cutter blades. John Hansen. U. S. 2,082,832, June 8, 1937 (Aug. 27, 1934; renewed March 15, 1937). In a machine for producing a series of adjacent scallops in one edge of a cutter blade, the combination of an abrasive wheel and means for rotation thereof.

Machine for grinding toothed wheels. Gear Grinding Co., Ltd., and A. H. Orcutt. Brit. 465,374, May 20, 1937 (Feb. 1, 1936).

Machine tool carriage control. A. P. Steiner (Landis Tool Co.). U. S. 2,083,748, June 15, 1937 (Nov. 11, 1933).

Manufacture of abrasive articles. E. C. Schacht (Behr-Manning Corp.). U. S. 2,082,182, June 1, 1937 (Nov. 20, 1931). In the art of preparing abrasive articles, wherein abrasive particles are deposited upon the adhesive surface of a backing, the steps comprise continuously feeding the particles as individually separated bodies to and through an electrical field in which the electrodes creating it are disposed entirely at one side of the carrier whereby the particles must pass through the field in their travel to the carrier, and passing the particles from the field to a continuously moving backing having an adhesive surface in a direction constituting an alteration of the action of the gravitational force due to the mutual repulsiveness of the particles and to the lines of force created by the field, whereby the particles are applied to the adhesively coated backing in dispersed relation.

Method of buffing and polishing articles. C. R. Moon (Ontario Mfg. Co.). U. S. 2,082,020, June 1, 1937 (June 7, 1935).

Method and means of shaping the operative surfaces of grinding wheels. A. Scrivener. Brit. 465,679, May 26, 1937 (Feb. 17, 1936).

Method and means for truing grinding disks. Zahnradfabrik Friedrichshafen Akt.-Ges. Brit. 465,874, June 2, 1937 (Aug. 13, 1934); addition to 454,089 (*Ceram. Abs.*, **16** [3] 80 (1937)).

Method of mixing. E. C. Ljungberg (Norton Co.). U. S. 2,082,545, June 1, 1937 (Feb. 16, 1937). A method of coating abrasive grain with ceramic bond comprises mixing a mass of grain, adding a plasticizer in powdered form, continuing the mixing, adding water, continuing the mixing, adding powdered ceramic bond by sifting, and continuing the mixing until each grain is coated with a substantially uniform amount of ceramic bond and there is no ceramic bond unattached to grain.

Pilot for valve-grinding tools. H. W. Zimmerman (Automotive Maintenance Machinery Co.). U. S. 2,084,175, June 15, 1937 (Dec. 15, 1934).

Precision grinding machine. Churchill Machine Tool Co., Ltd., and H. H. Asbridge. Brit. 465,210, May 20, 1937 (Nov. 12, 1935).

Profiling and dressing grinding wheels, more particularly for grinding screw threads. H. Lindner. Brit. 465,869, June 2, 1937 (May 23, 1936).

Reinforced abrasive member and method of making. A. W. Coffman (H. H. Robertson Co.). U. S. 2,082,150, June 1, 1937 (June 11, 1935). As a new article of manufacture, an abrasive member provided with pores throughout, a metal backing member of substantial thickness and strength, and a relatively thin layer of metallic adhesive interposed between the backing member and the abrasive member and extending into the pores of the adjacent surface only of the abrasive member to key it thereto and alloyed to the backing member whereby the abrasive member is rigidly secured to the backing member solely by the interposed layer of metallic adhesive and which constitutes a metallic bond, the porous nature of the abrasive member permitting it to be ground down substantially to the metal bond provided by the metal adhesive.

Rubber-bonded abrasive article. C. S. Nelson (Carborundum Co.). Can. 364,295, Feb. 23, 1937 (May 14, 1935). D. E. Webster (Norton Co.). Can. 363,892, Feb. 2, 1937 (Jan. 22, 1936). G.M.H.

Siliceous abrasive product. A. B. Cummins (Johns-Manville Corp.). Can. 363,351, Jan. 12, 1937 (June 4, 1935). G.M.H.

Soluble silicate binders and products made therewith. N. P. Pitt and A. F. Gill. Brit. 464,967, May 13, 1937 (June 15, 1936).

Tool for dressing grinding wheels. F. E. Koebel

(J. K. Smit & Sons, Inc.). Can. 363,241, Jan. 5, 1937 (April 20, 1936). G.M.H.

Truing apparatus for lapping machines. H. S. INDGE (Norton Co.). U. S. 2,082,736, June 1, 1937 (Sept. 28, 1935).

Art and Archeology

Archeology of Latin America. ANON. *Discovery*, **17** [204] 365–66 (1936). H.H.S.

Caracol at Chichen Itza. R. K. WAKELY. *Discovery*, **17** [204] 376–77 (1936).—The most perplexing of the great ruins of the Maya city is the building called the Caracol. Its purpose is a matter of conjecture, and it can not be dated with certainty. H.H.S.

Ceramic discussions. RAOUL DE BLOTTEFIÈRE. *Céram., Verrerie, Email.*, **5** [1] 5–12; [3] 85–94 (1937).—In the production of single art pieces decorated with flambé glazes and crystallized and mat enamels, where the effect of furnace atmosphere, temperature, and fire plays a decisive part, a muffle kiln guarantees the best results. The muffle kiln used by B. to obtain artistic pieces is described. In the production of flambé glazes there is an exact state of the enamel in the furnace at which the transformation of the coloring oxides by reduction takes place; this state corresponds to the moment when, after having been spread on the pieces, the enamel is not yet solidified and is still soft. For enamels fusing at 1150 to 1270° this state exists at 600 and 700°C. If this operation occurs too soon, while the enamel is still liquid, bubbles are formed; if too late and the enamels are solidified, the reduction does not take place and the carbon of the gases blackens the specimens. The oxides for flambé glazes are (1) cobalt oxide, which gives blues in silicates and carbonates; (2) nickel oxide, which gives yellow-browns and violet-browns in vitreous materials; (3) Fe_2O_3, resulting in yellows, reds, and red-violets in oxidizing flame and bluish green in reducing flame; (4) manganese oxide for yellow-browns, violets, and blacks; (5) copper oxide, which gives blue or green in oxidizing flame and reds in reducing atmosphere (long continued reducing flame gives metallic copper); (6) uranium oxide, which gives greenish or brownish yellow in oxidizing flame and grays and blacks in reducing flame; (7) chrome oxide for green tones; with the addition of calcium carbonate and tin oxide and by preliminary calcination it gives rose-pinks and reds; (8) titanium oxide mixed with iron oxide for orange tones; (9) antimony oxide with lead oxide, which gives Naples yellow below 800° and dark brown above 800°; (10) zinc oxide with chrome oxide for canary yellow; (11) tin oxide, which does not dissolve but floats and which, in fused silica, opacifies it forming a milky white; (12) platinum, iridium, and associated metals which give silicates a gray or black color; and (13) gold, giving a ruby tint. The combinations of these colors are unlimited. By the superposition of flambé enamels on nonflambé, surprisingly beautiful effects are obtained. The difficulty of decorating with crystallized glazes does not lie in obtaining the crystallizations, but in the impossibility of precision in the points where crystallization is desired; during fusion certain materials combine with the silica of the silicates and, on cooling, crystallize out instead of remaining in the amorphous state. To obtain crystallizations which are separate, well-formed, and grouped, the essential condition is to maintain the state of superfusion of the glaze for a long time; the localizations of crystals depend on the more or less easy flow of the glaze in fusing. This is the explanation of the presence of feldspar in many of the formulas which B. gives for silicate solvents, as it prevents excessive fusibility and augments the viscosity. Other formulas and tables are given, showing the composition of crystallizing silicates and mat enamels for producing satiny effects. M.V.C.

Control of crystalline glazes. F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **20** [7] 217–24 (1937).

Decorating glass: I, Spraying process. V. H. REMINGTON. *Glass Ind.*, **18** [5] 149–52 (1937).—Glass-decorating enamels are essentially low-fusing lead borosilicate glasses to which an oxide or a mineral pigment has been added. By obtaining the enamel in extremely fine powder form it is possible for the user to make mixtures that can be used for any of the various glass-decorating methods. For spraying, the principal vehicles are (1) turpentine and (2) water and alcohol. The turpentine, containing 8 to 12 oz. of oil of copaiba per gal. to insure smooth, uniform application, is best for production speed, although the other vehicle is less expensive and gives satisfactory results where speed is not required. Thorough mixing of the glass enamel in its vehicle is essential, and a ball mill or burr-type paint mill gives the best results. As glass can not be given a uniform coating of enamel by dipping, the spray gun must be used for applying it. The necessary equipment is described. Check should be kept on the amount of enamel being applied to each piece to maintain uniformity of color. Enamel defects include (1) blistering, caused by dust, lint, oil, or moisture on the ware, oil or rust in the air supply, or allowing sprayed ware to become dusty before firing; (2) reduction of the lead in the enamel due to nonvolatile oils in the vehicle or reducing conditions in the firebox, producing grayish casts in light colors; (3) crawling, due usually to a film of oil or grease on the ware caused by careless handling; (4) sweating of the ware causing sprayed color to fire improperly; and (5) crazing, due to too great variation of the coefficient of expansion of the glass and the enamel. E.J.V.

Delft pottery model of a sledge. WILLIAM KING. *Brit. Museum Quart.*, **11** [1] 16 (1936).—The British Museum has acquired by gift from F. Laura Cannan an unusual piece of delft in the form of a sledge decorated with skating scenes in enamel colors and gilding in the style of Meissen, 1730. Illustrated. H.H.S.

Discovery of pottery site of Yueh ware. J. M. PLUMER. *Illus. London News*, **190** [5108] 453–55 (1937).—P., who in 1935 discovered the site of the Sung ware pottery, has now discovered the Chekiang pottery which made the *pi se yao*, or "secret color" ware, for the princess Wu Yueh who ruled at Hangchow A.D. 907–927. Among the finds is the earliest dated pottery yet found in China. These excavations are regarded as of world importance. Local

farmers have been using the pottery waste for building material. H.H.S.

From torch to candle. F. W. ROBINS. *Discovery*, **18** [205] 10–13 (1937).—A historical account of torchlight holders and candlesticks through the ages is presented. Illustrated. H.H.S.

Glass wall in city building. ANON. *Sydney Morning Herald*, May 21, 1937.—The first building in Australia to have an outer wall of glass has been erected for an assurance firm. The ground floor face is of glass brick; the upper floors have opaque sheets of glass with as many and as large windows as possible. H.H.S.

Krebs, Danish artist in stoneware. ANON. *Danish Foreign Office Jour.*, **191**, 155 (Dec., 1936).—Exhibitions of Nathalie Krebs' work have been held in Denmark, Norway, and Sweden. The British Museum ceramist, J. L. Hobson, believes that hers is the best contemporary work. H.H.S.

Mysterious bowl in Egyptian tomb. W. B. EMERY. *Illus. London News*, **190** [5106] 348–49 (1937).—Among the antiquities from a nobleman's tomb excavated at Sakkara is a mysterious vessel of a type new to archeology. Its form was hitherto unknown, and its purpose is undiscovered. Illustrated. H.H.S.

Pachacamac, a holy city. R. G. WALKER. *Discovery*, **17** [204] 372–73 (1936).—Excavations are being made of the temples of what was the holy city of central Peru. H.H.S.

Paget collection of porcelain. WILLIAM KING. *Brit. Museum Quart.*, **11** [1] 15–16 (1936).—The British Museum has acquired by gift from F. Howard Paget a collection of 150 pieces of porcelain, mainly English. Derby biscuit porcelain is particularly represented. Illustrated. H.H.S.

Preserving a Roman kiln. CURRAH CRAWHALL. *Discovery*, **18** [205] 19–21 (1937).—A pottery kiln in almost perfect preservation, dating back to Roman Britain, has been transferred from its site at Compton, near Aldworth, Berkshire, to the S. Kensington Museum, London. The kiln, which is of clay, was isolated from the surrounding chalk which had preserved it intact and, encased in reinforced concrete, was taken safely by road to London. H.H.S.

Red and yellow ceramic colors: II, Yellow colors, with special reference to ivory porcelain. HANS KOHL. *Ber. Deut. Keram. Ges.*, **17** [12] 597–622 (1936).—Complete information is given on the production and application of iron yellows, Naples yellows, cadmium yellow, uranium yellow, rutile yellow, chromates, silver azure, the rare earths, chrome-titanium-antimony yellow, and vanadium hard-fire yellow. An account is given of experiments on ivory glazes for earthenware and porcelain using manganese, cerium, and combinations of these as the coloring agents. The results of all the experiments are given in tabulated form. For Part I see *Ceram. Abs.*, **14** [10] 238 (1935). E.J.V.

Roman forum found at Leicester. KATHLEEN M. KENYON. *Illus. London News*, **190** [5104] 254–56 (1937).—Found during excavation for a municipal bath, the forum is evidence of 18 centuries of civic continuity at Leicester. Illustrated. H.H.S.

Uranium red as an underglaze color. JACOB KLUG. *Keram. Rundschau*, **44** [26] 303–304; [27] 316–18 (1936).—The red color is due to lead uranate and is obtainable only in glazes of basic character and high lead content. Above 1020°C, the color is unstable. K. increased the alumina content to create a stain able to resist solution by the covering glaze. He tested both underglaze color and covering glaze. Practical results are summarized as follows: (1) alumina is favorable to glaze and underglaze reds; (2) high alumina content is a protection even against acidic covering glazes; (3) kaolin should be partly added to the mill; (4) silicate of alumina is a stabilizer of color; (5) the refractory stability of uranium red is increased by alumina; (6) for underglaze red, firing temperature above Seger cone 04 is not permissible; (7) covering glazes should contain 1 : 1.3 to 1.5 basic to acidic components; (8) the lead oxide content should be red glaze 68 to 75%, underglaze 65% and upward, and covering glaze 50 to 55%. The new underglaze process gives coral red without muffle fire. Tests for underglaze violet are undertaken. F.E.V.

BOOKS

Artist in Commerce. LEONARD SHARPE. A. & C. Black, Ltd., London, 1936. vi + 151 pp. Price 3s 6d. H.H.S.

Olympia. W. HEGE AND G. RODENWALDT. Sidgwick & Jackson, London, 1936. Price 21s. Reviewed in *Discovery*, **17** [204] 394 (1936).—The book contains 94 quarto plates and 32 half-tone illustrations of ancient Greece. H.H.S.

PATENTS

Designs for:

Ashtray. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 104,866, June 8, 1937 (Oct. 1, 1936).

Bottle. JOHN BLANDY. Can. 363,963, Feb. 9, 1937 (Feb. 9, 1935). G.M.H.

Bottle. J. L. DUNNOCK (Swindell Brothers, Inc.). U. S. 104,835, June 8, 1937 (Jan. 18, 1937). E. W. FUERST AND B. D. FUERST (Owens-Illinois Glass Co.). U. S. 104,656, May 25, 1937 (April 14, 1937). P. G. LLOYD (Carr-Lowrey Glass Co.). U. S. 104,666, May 25, 1937 (April 14, 1937).

Centerpiece. FINDLEY WILLIAMS (Fostoria Glass Co.). U. S. 104,712, May 25, 1937 (April 10, 1937).

Chimney top. E. D. WAGNER (Robinson Clay Product Co.). U. S. 104,620, May 25, 1937 (March 12, 1937).

Cover glass. S. L. LEBBY (Corning Glass Works). Can. 363,703 and 363,704, Jan. 26, 1937 (Jan. 7, 1936). G.M.H.

Goblet. E. M. BOTTOME (Fostoria Glass Co.). U. S. 104,718, June 1, 1937 (April 10, 1937). E. W. FUERST (Libbey Glass Co.). U. S. 104,844, June 8, 1937 (Oct. 30, 1936). GEORGE SAKIER (Fostoria Glass Co.). U. S. 104,703, May 25, 1937 (April 10, 1937).

Jar. B. D. FUERST (Owens-Illinois Glass Co.). U. S. 104,659, May 25, 1937 (April 14, 1937).

Jug. E. W. FUERST AND B. D. FUERST (Owens-Illinois Glass Co.). U. S. 104,657, May 25, 1937 (April 14, 1937).

Plate. E. M. BOTTOME (Fostoria Glass Co.). U. S. 104,717, June 1, 1937 (April 10, 1937). H. O. EBELING (Ebeling & Reuss, Inc.). U. S. 104,836, June 8, 1937 (March 20, 1937). DORIS JOHNSON (Mayer China Co.). U. S. 104,784, June 1, 1937 (April 19, 1937). W. T. JOHNSON (Mayer China Co.). U. S. 104,783, June 1, 1937 (April 19, 1937).

Production of precious metal decorations on ceramic objects. ALWIN HEFTER (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). U. S. 2,081,234, May 25, 1937 (Jan. 9, 1935). A method of decorating a ceramic surface comprises applying thereto a lacquer containing bismuth and thereafter applying precious metal powder on the lacquered surface.

Cements

Chemical considerations underlying the manufacture of Portland cement. W. WATSON AND Q. L. CRADDOCK. *Cement*, **8** [9] 213–20 (1935).—Consideration is given to the directions from which high-strength cements may most likely be obtained by modification of the composition of the mixtures. Since the four major constituents of cement are lime, silica, alumina, and iron oxide, the composition of the raw material mixture may be fixed by the following ratios:

$$(1)\quad \frac{\text{CaO (mols)}}{\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 \text{ (mols)}}$$

$$(2)\quad \frac{\text{SiO}_2\ (\%)}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3\ (\%)} \qquad (3)\quad \frac{\text{Al}_2\text{O}_3\ (\%)}{\text{Fe}_2\text{O}_3\ (\%)}$$

Ratio (1) gives the actual basicity of the raw mixture and is called the "theoretical lime ratio." The lime ratio specified in the British Standard Specifications for Portland cement is the molecular ratio $\frac{\text{CaO}}{\text{SiO}_2 + \text{Al}_2\text{O}_3}$, while the hydraulic modulus, frequently referred to in U. S. publications, is the percentage ratio $\frac{\text{CaO}(\%)}{\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3(\%)}$. The lime ratio should be as high as possible with soundness. It increases the early strength but also renders the clinker easier to grind. Both tensile and crushing strength increase gradually with the lime ratio; at a certain point the tensile strength decreases. When limits of soundness are approached, crushing strength also fails. Raw mixtures should be finely ground to raise the lime content. Values of the theoretical lime limit are about 2.7 to 2.75, the actual limits depending upon the nature and composition of the raw materials. Studies on the silica ratio show that when (2) rises to 3 or more the cement becomes slow setting. With the values of 2.7 or more, cements are usually slow hardening, while one with the value of 1.8 or less is usually rapid hardening. High siliceous raw materials are difficult to clinker and, unless finely ground, combine with difficulty. Siliceous mixtures containing silica in soluble form combine more readily in the kiln than do raw mixtures containing all or part of the silica in an insoluble form. Siliceous clinkers are uniformly small in size. Cements with high SiO_2 ratios are of slow setting nature. The more siliceous the cement, the more resistant it becomes to injurious external influences. Increasing the Fe_2O_3 content at the expense of Al_2O_3 lengthens the time of set. The values of the silica ratio and alumina-iron oxide ratio must be considered together, an increase in one ratio necessitating a corresponding increase in the other. MgO can not be assumed to act equally and equivalently with CaO. Slow expansion renders the use of cement containing high MgO, dangerous. MgO content can be increased to 7% before a noticeable decrease in strength occurs. Cements of high MgO content develop a quick set accompanied by great evolution of heat. With marked increase of MgO, difficulties in clinkering the raw materials increase considerably. Recently it has been claimed that high MgO favors rapid hardening. The calcining and clinkering processes are intensified, even to the point of double clinkering.

G.R.S.

Constitution of quenched slags used in the manufacture of metallurgical cements. TRAVERS. *Verre & Silicates Ind.*, **8** [5] 53–56; [6] 61–64; [7] 73–75 (1937).—Metallurgical cements, which are growing in importance, are composed mainly of granulated blast-furnace slag (80 to 90%) and calcium sulfate (5 to 15%) with or without additions of ordinary clinker or hydraulic lime. After one month they have a mechanical resistance comparable to that of the best Portland cements and have the added advantage of resisting disintegration by water, especially sea water. Setting is slower than that of Portland cements, and even after several days they show less resistance than the latter. In the experiments undertaken to study the constitution of quenched slag, which is the chief component of metallurgical cements, the slag was considered as a glass, as a pozzuolana, or as a permutite. Conclusions are as follows: Slag can not be considered as a pozzuolana or as a zeolite; it can be compared only partly to a glass. Because of the poor conductivity of this complex, the quenching is only superficial, and the interior of the grains cools less rapidly than is believed. Quenching is necessary to prevent reactions in the solid state (transformation of β-dicalcium silicate into nonhydraulic γ-silicate), but it does not prevent the establishment, at least partially, of the equilibrium at the moment of solidification; one should therefore expect to find in quenched slag the constituents provided for by the equilibrium diagram, *viz.*, dicalcium silicate and gehlenite, and to verify the absence of aluminates. (*a*) The hydraulic properties of slag alone can be explained by the aid of β-dicalcium silicate. Like the latter, slag sets slowly when cold and rather rapidly in the autoclave; in the two cases it is a simple hydration. If β-dicalcium silicate is refired or the slag is quenched at 800°, its hydraulicity is removed with the transformation of β-dicalcium silicate into γ-dicalcium silicate. (*b*) The effect of the addition of calcium sulfate and lime to slag can be reduced to the action of the salt on the second constituent of equilibrium of slag, gehlenite. There is a parallelism between the two actions except that slag can fix the sulfate without the addition of lime, probably because of the liberation of the sulfide of calcium which gives the necessary alkalinity. Attention is called

to the interest presented by the study of the physicochemical properties of liquid slag before quenching; it is believed that the initial temperature of quenching is related to the reactivity of slag because the molecular state of the constituents of this liquid is probably a function of the temperature and becomes simpler as the latter increases. The physical constants of liquid slag are difficult to measure because of the high temperatures. M.V.C.

Determination of aluminates of lime in hydraulic products. A. TRAVERS AND F. CLAUSE. *Verre & Silicates Ind.*, 8 [11] 128–31 (1937).—The approximate analysis of hydraulic binding agents before and after setting is essential for understanding setting reactions and the resistance to different corrosive agents of the products obtained. The chemical method of determining aluminates which is used here is based on the simplest and most characteristic property of these salts, *viz.*, their solubility in distilled water. In an attempt to make the reaction almost quantitative, boiling water was used instead of cold water, with suitable conditions of dilution and of p_H. The technique is as follows: anhydrous or hydrated aluminate (sifted with a No. 140 screen) is rapidly treated with a suitable volume of boiling water well de-aired and protected from CO_2 of the air. The experiment lasts from 5 to 15 min. The initial p_H of the medium and the dilution is calculated in advance (1) to prevent the hydrolysis of the salt and (2) to remain below the saturation of the hydrate of cubic aluminate, stable only in the conditions of the experiment, *i.e.*, $Al_2O_3 3CaO 6H_2O$ hexahydrate of Thorvaldson; the solubility of this salt as an anhydrous salt is 0.3 g./liter at 100°. In the case of anhydrous monocalcium aluminate, 0.2 g. of $Al_2O_3 \cdot CaO$ and 0.05 g. of CaO in 500 cc. of boiling water are used. In the case of hydrated aluminates with the formula Al_2O_3 $(3 + x)$ CaO·Aq., x varying from 0 to 1, the addition of lime is not necessary because (the aluminate stable at 100° being $Al_2O_3 \cdot 3CaO \cdot 6H_2O$) the lime corresponding to the excess x in proportion to the tricalcium suffices to give the necessary alkalinity to prevent hydrolysis. In this case 0.2 g. of salt is used, but as an anhydrous product dried with H_2SO_4 and sifted with a No. 140 screen. At the end of about 10 min. boiling, a completely clear liquid is obtained which does not become cloudy with longer boiling when protected from the CO_2 of the air. The applications of the method to different types of cement are given. M.V.C.

Determination of free lime and calcium hydroxide in cement clinker, slag, and set hydraulic mortars. P. SCHLÄPFER AND P. ESENWEIN. *Schweizer Arch. Angew. Wiss. Tech.*, 2, 283–96 (1936); abstracted in *Chem. Zentr.*, 1937, i, 2848. M.V.C.

Hydration and hardening of calcium aluminates and silicates. W. WATSON AND Q. L. CRADDOCK. *Cement*, 7, 371–79 (1934).—Setting time increases as the percentage of CaO increases in the calcium aluminates which may exist in Portland cement. The influence of gypsum on setting time varies with the aluminate. $3CaO \cdot 5Al_2O_3$ and $CaO \cdot Al_2O_3$ are quickened while for $5CaO \cdot 3Al_2O_3$ the time is lengthened; $3CaO \cdot Al_2O_3$ reacts too rapidly for additions of gypsum to make any marked difference. The influence of the amount of water on setting is discussed, and the process of hydration is treated under hydration in excess water, in limited amounts of water, and in limewater. Probably the only silicates which occur to any extent in good clinker are $3CaO \cdot SiO_2$, β-$2CaO \cdot SiO_2$, and α-$2CaO \cdot SiO_2$. β-$2CaO \cdot SiO_2$ sets slowly and even with gypsum added it sets and attains strength too slowly to be of any commercial value when used alone. $3CaO \cdot SiO_2$ hydrolyzes more rapidly than β-$2CaO \cdot SiO_2$ and sets normally. Addition of gypsum reduces the initial set slightly but does not affect the final set. Briquets have good strength at the end of 7 days. Hydration of both silicates produces calcium hydroxide and amorphous hydrated calcium silicate approaching the composition $CaO \cdot SiO_2 \cdot xH_2O$. The extent of hydration depends upon the quantity of water used. G.R.S.

Metallurgical cements. A. O. PURDON. *Verre & Silicates Ind.*, 8 [8] 86–89; [9] 97–100; [10] 116–21 (1937).—The use of cements made with slag was retarded for a long time by the opposition of certain industrial interests and the conservative attitude of the public, although where initial hardness is not required they have as good or better resistance than pure Portland cements, especially in regard to traction. Metallurgical or slag cements are classified according to the proportion of slag into three groups: (1) iron Portland cement: slag 30%, Portland cement 70%; this type is no longer important as the excess Portland cement makes it more vulnerable to corrosive waters, and it is more expensive without necessarily contributing a higher mechanical resistance; (2) blast-furnace cement: slag 70%, Portland cement 30%; this type gives the best results, and most metallurgical cements today belong to this group; (3) permetallurgical cement: slag 85%, Portland cement 15%; this is a slow setting cement with very high final resistance. Recently cements with a slag base, called "supersulfated cements," have appeared; they are obtained by crushing about 4 parts slag to 1 part anhydrite (sulfate of anhydrous calcium) with a small addition of lime or Portland cement. These give good results and are resistant to water containing calcium sulfate. The optimum proportion of slag to Portland cement varies within rather large limits according to the chemical composition of the materials; therefore the current practice of arbitrarily fixing the percentage of slag in a metallurgical cement should be discontinued. Tables and graphs show exact resistance values and course of hardening of slag and Portland cements. M.V.C.

Method for approximating the glass content of Portland cement clinker. WILLIAM LERCH AND LORRIN T. BROWNMILLER. *Jour. Research Nat. Bur. Standards*, 18 [5] 609–22 (1937).—The method involves a determination of the heat of solution of the original clinker and of the same clinker which has subsequently been annealed under conditions designed to produce complete crystallization. The difference between the heat values so obtained is due principally to the latent heat of crystallization of the glass present in the original clinker. The ratio between that value and the latent heat of crystallization of the glass phase represents the glass content of the clinker. A curve is given showing the latent heat of crystallization of all possible glass compositions obtainable from melts at 1400°C in the system CaO–Al_2O_3–SiO_2–Fe_2O_3 between the Al_2O_3/Fe_2O_3 ratios of 0.64 and 3.24. R.A.H.

Plaster, its constitution, manufacture, and utilization in

ceramics. RAOUL DE BLOTTEFIÈRE. *Céramique*, **39** [576] 45–58 (1936).—The physical and chemical properties of plaster, its working, and its firing in various types of kilns are discussed in detail. M.V.C.

Porcelain cements. C. VITTORI. *Chimica & Industria*, **18** [7] 349–53 (1936).—Several Italian porcelain cements were analyzed as to their contents of free Ca in various stages of setting and hardening under water and in vapor. They have, particularly with additions of clinkers, the characteristics of a high-grade cement with respect to initial strength and resistance to chemical decomposition; they are slightly permeable and become harder with time. M.H.

Trends in the manufacture and control of cements. Q. SESTINI. *Chimica & Industria*, **18** [8] 401–402 (1936).—The various types of cements and their particular fields of application are discussed. Portland cement is classified as follows: (1) standard type, for ordinary constructions, (2) cement with low heat of hydration, small shrinkage, and progressive strength, (3) cement with high strength and quick setting (supercement), and (4) cement resistant to chemical attack (salt and sulfated water). Class (1) cement is a tricalcic silicate (or alite), (2) is a bicalcic silicate (or belite), (3) is a tricalcic alumino-ferrite (or brownmillerite), and (4) is a tricalcic aluminate (about $5CaO{\cdot}3Al_2O_3$). Methods of producing these cements and the determination of free CaO, Al_2O_3, Fe_2O_3, and other constituents are described. M.H.

BOOK

Calculations of Raw Materials and Computation of the Material Balance of the Production of Portland Cement. M. P. ZHUKOV. Edited, with a preface, by P. P. Budnikov. Kharkov, 1937. The book contains all calculations of the composition of the raw materials mixture by the methods of Michaelis, Mead, Bogue, Kühl, and Kind. A calculation of two-component, three-component, and three and four-component mixtures is given. The raw material mixture for magnesium-Portland cement clinker is calculated. Kind's and Bogue's methods of calculation of the mineral composition of Portland cement clinker are given. Examples of calculations of the raw-material mixture and computation of the material balance of a Portland cement plant are given. The book contains valuable information for workers in cement plants and for students. E.S.

PATENTS

Cement and process of making. G. W. JORDAN. U. S. 2,083,267, June 8, 1937 (Nov. 1, 1934).

Cement raw material treating apparatus. MIKAEL VOGEL-JORGENSEN (F. L. Smidth & Co.). Can. 363,406, Jan. 12, 1937 (Aug. 26, 1935). G.M.H.

Magnesium oxychloride cement. H. H. ROBERTSON CO. AND D. S. HUBBELL. Brit. 465,240, May 20, 1937 (July 31, 1936).

Pressed calcium oxide or hydroxide powder. ERNST WINTER AND FRIDOLIN HARTMANN (Akt.-Ges. für Stickstoffduenger). Can. 363,324, Jan. 12, 1937 (Jan. 19, 1931). G.M.H.

Process of making cement. L. T. WORK. U. S. 2,083,179, June 8, 1937 (Oct. 10, 1934). In the process of making cement involving the operations of subdividing essentially noncementitious materials consisting essentially of compounds of lime, alumina, and silica capable, upon sufficient heating in admixture, of reacting to form the main reaction products of a Portland cement composition, preparing a raw mixture of the subdivided materials, and causing the materials therein to react by heating it, the improvement consists in subdividing the materials of the raw mixture to a maximum particle size within the diameter range of from about 20 to about 70 microns, which maximum particle size increases with the decrease in the potential tricalcium silicate value of the raw mixture, and in heating the so-subdivided raw mixture at reaction temperature but below that temperature at which the main reaction products liquefy.

Rotary kiln for clinkering cement raw materials. MIKAEL VOGEL-JORGENSEN (F. L. Smidth & Co.). Can. 363,240, Jan. 5, 1937 (Jan. 16, 1936). G.M.H.

Enamel

Acid stability of enamel. VIELHABER. *Emailwaren-Ind.*, **14** [13] 99–100 (1937).—Acid stability of enamel does not depend on a definite part of the batch but depends to a very great extent on the ratio in which constituents of various raw materials are present in the batch. Silica has the greatest effect on acid stability of enamel insofar as the acid stability of the enamel generally increases with increased silica content. Fluorides are an undesirable factor. Several batches are analyzed. See *Ceram. Abs.*, **15** [9] 267 (1936). M.V.C.

Amazing development of an ancient art. JIM WOLF. *Amer. Enameler*, **9** [10] 5 (1937).—Practical aspects of porcelain enamel's place in architecture are pointed out. J.N.H.

Application of porcelain enamel to vehicles. ANON. *Emaillerie*, **4** [6] 24 (1936).—The porcelain enamel bodies set on the new Knudsen Corp. milk trucks in the U. S. and the porcelain enamel panels used on the East Indian Railway carriages in India are described. M.D.

Bonding porcelain enameled architectural panels to masonry. ANON. *Amer. Enameler*, **10** [3] 5 (1937).—A new method of bonding porcelain enameled metal panels to cement or plastics is presented. J.N.H.

Cleaning practice. ANON. *Amer. Enameler*, **10** [3] 18 (1937).—An interesting analysis of up-to-date methods of avoiding difficulties in the cleaner tank is presented. J.N.H.

Continuous process for smelting frits. ANON. *Amer. Enameler*, **9** [9] 5 (1937).—A complete description of the continuous smelting process is given. Continuously smelted frits are keyed to mass production. J.N.H.

Control of foundry sand. H. H. SHEPHERD. *Metal Ind.* [London], **49** [18] 436 (1936).—Foundry sands may best be controlled as follows: (1) Sand should be stored under cover. (2) To obtain standards and properly controlled mixtures, the shovelful measure should not be permitted. (3) A definite minimum milling time should be set. (4) Sand dumped from molds can not be properly tempered

immediately afterwards. (5) Sands of the correct grain size, uniformity, and permeability do away with the vent wire. (6) The molder must not be allowed to add other sands indiscriminately. (7) The amount of moisture must be kept as low as is consistent with the required bonding condition. (8) Silt and the troubles associated with it are more likely to come from coal dust than from possible breakdown of normal sand grains. (9) Precautions must be taken to eliminate metal shot from the sand. (10) Hot sand can cause rough castings due to the moisture condensing when the sand comes in contact with the cold pattern and causing the sand to stick to the pattern. H.E.S.

Defects in the manufacture of enamel. RICHARD ALDINGER. *Glashütte*, **67** [13] 221–23 (1937).—A great number of enamel defects and their changing properties, such as changes in expansion, luster, opacification, and chemical resistance, are accounted for by a deficient or inappropriate treatment of the enamel. A. discusses the important points in the mixing, firing, and cooling of the enamel. An enamel with invariable properties can be produced only after being thoroughly tested and only when the directions for working it are followed exactly. M.V.C.

Determination of physicochemical conditions for the adherence of enamel to metal. E. A. CHWASS. *Liteĭnoe Delo*, **7** [7] 39–42 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 2427.—C. discusses recent studies of the subject. M.V.C.

Determining impact strength of enamel by the hardness tester of Schwartz. LUDWIG STUCKERT. *Emailwaren-Ind.*, **14** [10–11] 81–84 (1937).—The Schwartz hardness tester consists of a steel tube 50 cm. in length and 40 mm. in diameter through which a ram of 0.25, 0.50, or 1 kg. falls (depending on the hardness of the enamel). The diameter of the place struck is also a measure determining the quality of the enamel. The Brinell hardness is determined likewise. M.V.C.

Development of leadless enamels. L. VIELHABER. *Emaillerie*, **4** [8] 9–12 (1936).—Gradually lead has been removed from kitchenware enamels and bath powder enamels. The latest step is the removal of lead from transparent enamels. In bath enamels more silica, sodium, and zinc oxides were introduced to supersede lead; antimony oxide could then be used in formulas since the formation of lead antimonate was no longer possible. Lead was replaced by barium oxide and fluorspar in enamels for stoves in order to keep transparency. Leadless enamels are usually cheaper and more acid resisting. M.D.

Do your own color matching. ANTHONY JOHN LUBERTINE AND JOHN ALBERT ZINGOR. *Amer. Enameler*, **10** [2] 5 (1937).—Tested methods and details of the use of the basic coloring oxides are presented. J.N.H.

Enamel fusibility. L. VIELHABER. *Emaillerie*, **4** [6] 25–27 (1936).—Raw materials lowering the melting point usually lower the expansion coefficient of enamels at the same time; borax does not increase expansion coefficient. As iron is dissolved from sheet iron in the ground coat during firing, the expansion of the ground coat is increased; thus proper ground-coat frits have expansion coefficients lower than those of cover-coat frits. The expansion coefficient of cast-iron enamels should be lower than that of the base metal. Clay or other mill additions increasing fusibility increase the expansion of enamels. Cast-iron powder enamel, however, must have the proper expansion to suit the particular metal to which it is applied. M.D.

Enamel shop inspection. ANON. *Emaillerie*, **4** [10] 9–16 (1936).—Checking parts after each stage of the work and before the next stages are performed reduces the amount of scrap. After cleaning, dirty cast iron should be re-blasted, and poorly pickled sheet iron should be sent back to pickling, or, if soiled with grease, to first chemical cleaning. Parts must be repaired, when necessary, as soon as they come from the pickling department. After every firing operation the ware should be controlled. White rubbing stones are used to take any lump off the fired ground coat. Patching work must be done and the ware refired before the second cover coat is applied. In order to control pieces when completed, standards should be kept for comparison. M.D.

Enamel stained by combustion gases of enameling furnaces. G. H. MCINTYRE. *Emaillerie*, **4** [11] 9–13 (1936). The scum produced on enameled parts was analyzed and was proved to be sodium sulfate. In the same way, delayed scumming was shown to be caused by dissolution in moisture of sodium sulfate from the enamel surface. Chemical analyses have shown that these salts came neither from the enamel frit nor from the mill additions, but from sulfurous gases leaking through the muffle. See "Influence—," *Ceram. Abs.*, **16** [6] 169 (1937). M.D.

Enameling principles. ANON. *Emaillerie*, **4** [10] 21–25; [11] 15–27; [12] 9–13 (1936).—Concise recommendations are made in regard to any operations upon which the success of enameling depends. Good iron composition is given. Chief items of cleaning, pickling, milling, dipping, spraying, and firing are given in directory form. The principal methods of checking the various operations are discussed. M.D.

Integral expansion of vitreous enamels between the softening point and room temperature. J. E. ROSENBERG AND A. LANGERMAN. *Jour. Amer. Ceram. Soc.*, **20** [7] 236–44 (1937).

Leadless enamels. ANON. *Amer. Enameler*, **10** [2] 22 (1937).—The advantages of leadless enamels in the enameling plant are discussed. J.N.H.

Making "continuous" furnaces continuous. ANON. *Amer. Enameler*, **9** [10] 7 (1937). J.N.H.

Mechanism of corrosion of metals. E. C. ROLLASON. *Welder*, **9** [39] 53–58, 61 (1937).—R. gives a review of the theory and corrosion behavior of various metals. W.H.B.

Metal cleaning before enameling: II, Sheet iron. ANON. *Emaillerie*, **4** [6] 9–23; [7] 9–12 (1936).—Grease and oil must first be removed from sheet iron by annealing or by chemicals. The former method is valuable only for deep drawn or flanged pieces. The latter method is to be preferred for all other pieces. Alkaline solutions are used instead of organic solvents which are expensive and often inflammable. The strength of the bath must be checked from time to time and its value kept constant. After the grease is removed from metal parts they are rinsed, preferably in hot water. They are then pickled either in 6%

H_2SO_4 at 150°F for about 1/4 hr. or in 11% HCl at room temperature for a longer time. With sulfuric acid, the iron content of the bath must not exceed 6%. Pickling is followed by a rinse in running hot water and in a neutralizing bath whose alkali content corresponds to 0.3% Na_2O, the temperature being 50°F. **III, Special pickling.** *Ibid.*, pp. 13–16.—In kitchenware enameling, iron sulfide may be added to sulfuric acid to make granite ware. Nickel baths are now used after the usual sulfuric pickling in the so-called nickel dip process. The nickel content of the solution varies, according to practice, from 30 to 60 g./liter, but the p_H value must be kept within a 5.2 to 6.8 range while the temperature is about 160°F. The cyanide method of nickel titration is described. For Part I see *Ceram. Abs.*, **15** [9] 269 (1936). M.D

Mill addition: III, Color oxides. ANON. *Emaillerie*, **4** [8] 17–27; [9] 17–22 (1936).—The preparation of coloring pigments is briefly outlined. Frit composition influences the shade of color of enamel, *e.g.*, zinc oxide gives rise to brighter blues. Frit, therefore, must be chosen according to the color of enamel desired. Dark blue enamels should be prepared from blue frits. For white enamel a white opaque frit must be used with an opacifier. Opacifiers are added to the mill for light colors. When matching color from sheet iron in cast-iron enamel, the color oxide addition will be different, *e.g.*, less color oxide is needed in gray cast-iron than in gray sheet-iron enamel, but a deeper blue oxide is necessary in cast-iron than that in sheet-iron enamel. Red enamels must be carefully fired as they have a tendency to fire out. Black enamels develop their color by higher and longer firing, and therefore blacks are more difficult to obtain with cast-iron enamels. For Parts I–II see *Ceram. Abs.*, **15** [9] 269 (1936). M.D.

"Mineral spar" as enamel raw material. A. DIETZEL. *Emailwaren-Ind.*, **14** [14] 105–107 (1937).—Experiments disproved the assumptions of Ottersbach (*Ceram. Abs.*, **16** [2] 58 (1937)) that (1) "mineral spar" is a material which produces a white enamel in spite of its high Fe_2O_3 content, (2) it is a powerful opacifier permitting the elimination of Sn_2O_3, and (3) it markedly improves acid stability of the enamel. "Mineral spar" can be used successfully for ground or coat enamels or for white coat enamels if the requirements for the white content of the finished ware are not high. M.V.C.

Modern nonferrous foundry equipment. J. LAING. *Metal Ind.* [London], **49** [21] 505–509; [22] 531–34 (1936).—With the exception of the practical application of the principle of making cores by means of blowing sand into an enclosed box, there have been few recent striking developments in foundry plants. Manufacturers, however, have in many instances considerably improved their products, both from the foundry and engineering point of view. Sand-mixing machines, molding machines, core-making machines, and drying stoves of the latest type are explained and illustrated. H.E.S.

Opacification of enamel as a phenomenon of time. LUDWIG STUCKERT. *Emailwaren-Ind.*, **14** [8] 59–61 (1937).—The increase in opacification through longer firing takes place only in an enamel which is not treated with opacifiers; in the presence of opacifiers, only a 10% increase in the initial opacification occurs. The dependence of opacification on time depends, to a considerable extent, on the dissolving of the enamel solution which is in disequilibrium. The crystallization of a strongly undercooled solution as represented by fired enamel is determined by two factors entirely independent of each other: (1) the number of nuclei, *i.e.*, the number of crystallization centers; and (2) the rate of growth of the crystals. M.V.C.

Porcelain enamel in modern kitchen furniture. ANON. *Emaillerie*, **4** [7] 24–25 (1936).—Some fine pieces of kitchen furniture in porcelain enameled sheet iron made in the U. S. are shown. M.D.

Primary oxide film on iron. H. R. NELSON. *Jour. Chem. Phys.*, **5** [4] 252–59 (1937).—The identity and structure of the invisible, air-formed oxide film on iron has never been determined although the practical importance of a knowledge of its properties in the study of corrosion has been demonstrated. Electron diffraction experiments showing this film to be structurally identical with Fe_3O_4 are now reported. In addition, it was found that the oxide has a definite orientation relationship with the underlying iron, *i.e.*, the [210] directions in the oxide crystals are parallel to the [111] directions in the iron. Freshly abraded surfaces of electrolytic and ingot iron were investigated. Evaporated films of electrolytic iron were prepared in the diffraction camera, and pictures taken before and after exposure to air show that Fe_3O_4 forms rapidly in dry air at room temperature. An air pressure of 10^{-6} mm. for a few minutes gave a measurable effect. Exposure to air at atmospheric pressure for longer than a few minutes did not greatly strengthen the pattern. The factors affecting the sensitivity of this method of examining thin films on metals are discussed. G.R.S.

Quality of enamel and muffle kilns for obtaining high-grade enamelware. H. M. *Glashütte*, **67** [8] 131–32 (1937).—M. discusses the manufacture of high-quality enamelware with special regard to the process of firing in muffle kilns. M.V.C.

Solubility determinations on acid-resisting vitreous enamels. O. KRÜGER. *Korrosion & Metallschutz*, **12**, 85–88 (1936).—The rate of attack of HCl, H_2SO_4, and HNO_3 on ground enamels and enameled vessels was determined at 99° over the range of acid concentration from 1/8 to 5 *N*. Determinations were made gravimetrically, by titration, and by electrical conductivity measurements. Detailed results are given in three large tables. J.B.A.

Tensile tests of weld metal at varying temperatures. T. R. B. SANDERS. *Welder*, **9** [39] 38–41 (1937).—Original research on all-weld metal for temperatures of 15° to 700°C is described. A table is included giving approximate elastic limit, maximum load, total elongation and elongation up to point of maximum load, and neck-diameter after fracture for the various testing temperatures. The British standard sample used for metal is deposited from Murex Cresta electrode and is tested in S.'s tensile machine built for uniform rate of loading. Stress strain diagram for all samples indicates the presence of residual stress which is considered the reason for the lack of definite yield point. Highest breaking load found for the test is at 240°C, and temperature increase thereafter consistently decreases strength. Extension up to the point of maximum load also falls off consistently with temperature increase. W.H.B.

Vitreous enameling in the Soviet Union. J. H. GRAY. *Amer. Enameler*, **10** [3] 7 (1937).—G. gives an interesting analysis of production methods, trends, and progress of the porcelain enameling industry in the U.S.S.R. J.N.H.

Wake up and live—with porcelain enamel. ANON. *Amer. Enameler*, **10** [1] 5 (1937).—Porcelain enamel is one of the most important mediums for expression of modern architectural design. J.N.H.

Welding cast iron. Review of the literature to Nov. 1, 1936. W. SPRAGEN AND G. E. CLAUSSEN. *Welding Jour.* [N. Y.], **16** [3] Supp. 2–32 (1937).—A thorough review is given of methods, materials, metallurgical factors, microstructures, physical and mechanical properties, and flame and other cutting methods. A number of research problems is suggested. The data from the literature are assembled in numerous tables and curves, and appendices give average properties of unalloyed cast Fe and cast steel, Monel, and 60–40 brazing rod. 340 references. W.H.B.

Welding cast steel. Review of the literature to Nov. 1, 1936. W. SPRAGEN AND G. E. CLAUSSEN. *Welding Jour.* [N. Y.], **16** [4] Supp. 2–11 (1937).—Tables include results of tests, from various sources, of physical and mechanical properties. The results are excellently indexed, and information on properties to be expected is made easily available. Good grades of C cast steel below 0.30% C are as easily welded as rolled steels of similar composition; higher C and alloy contents require special methods of welding. 86 references. W.H.B.

Winter troubles in the enamel shop. L. VIELHABER. *Emaillerie*, **4** [10] 17–19 (1936).—Owing to low temperature in the mill room, viscosity of the milled ground coat is irregular, resulting in a variable thickness of the layer applied. This accordingly causes under or over firing. Low temperature of the base metal has the same effect. When parts are dried at room temperature, drying being slow, mineral salts crystallize on the last wet spots, producing scumming. As far as possible, enamels and metal parts should be kept at 60 to 70°F. M.D.

SEPARATE PUBLICATIONS

Determination of residual strains and stresses in arc-welded plates. H. E. LANCE MARTIN. *Trans. North East Coast Inst. Engrs. & Shipbuilders*, 29 pp. (Advance copy, April, 1937.) M. discusses results of exact experimental studies and describes methods used in the measurement of stresses. Edge welds were made on annealed mild steel plates, and changes in 2-in. gage length placed on both faces of the plate before welding were determined after welding and after partial or complete release of residual strains. Several runs were made with one edge welded and with two opposite edges welded using $^3/_8$ in. thick stock, 0.18 C with maximum breaking stress of 28 to 32 tons/in.^{2}, Y. P. (unannealed) of 18 tons, 25% elongation in 8 in., and modulus of 13,250 tons/in.^{2}. Strains on 2-in. gage length were measured by optical (microscope) spotting of small indents on a polished surface (presumably Vickers hardness indents), the gage length being laid out on a milling machine with the aid of specially prepared distance pieces. Changes in gage length measured with a microscope comparator which was calibrated with a type of interferometer were divided into elastic and plastic strains. The amount of recovery of gage length after complete stress relief at 650°C in H_2 atmosphere was subtracted from the original length giving figures for overstrain and strains that remained elastic. The amount of relief in stress was calculated from the measured strain and set as equal to residual stress in the plate with the proviso that the figure be regarded as average for the position in the plate over the gage length measured, since the strain varies over the gage length. The same measurements were carried out for the single Vee, three pass, butt-welded joint, all welding tests being for unrestrained movement of the material during welding except for the Vee butt weld which was restricted. The conditions of welding were held constant using 150 cycle a.-c., No. 10 and No. 8 gage electrodes at 100 and 125 amp., respectively, at a speed of $4^1/_2$ in./min.; average depth of deposit was determined by weighing plates before and after welding. Data on strain measurements are given in numerous tables together with elastic recoveries by cutting sections tranverse to the weld outside of gage length (partial recovery) and for complete recovery after thermal stress relief. The cause of distortion in welding is visualized as restricted compressive stresses set up in heating becoming residual tensions due to restricted tensile stresses on cooling. Curves are given for residual strains *vs.* distance from weld, showing the region of elastic strain starting approximately $1^1/_2$ in. from the welded edge; for some of the plates, part of the curves show linear variation of strain with distance from welded edge. It is suggested that the use of the restricted, butt-weld design used for the tests, together with measuring technique employed, will be of practical value for determining suitability of electrodes, parent metal as well as welder qualification, and welding process at low cost and high precisions. Illustrated. W.H.B.

Iron ore made into pig iron by the blast furnace. ANON. *Steel Facts;* reprinted in *Amer. Refrac. Inst. Tech. Bull.*, No. 65, 4 pp. (May, 1937). H.E.S.

Glass

Acceleration of drawing of thickened glass. M. G. CHERNYAK, V. V. ERLAND, A. A. GUREVICH, AND A. G. BELOKONSKIĬ. *Keram. & Steklo*, **13** [2] 17–24 (1937).—Experiments to accelerate the rate of drawing of thickened Fourcault glass are described. The Al_2O_3 content of the glass had to be increased to increase its viscosity. Illustrated. M.V.C.

Alteration of glasses and glazes by means of the capillary method. RÉNÉ DUBRISAY, HENRI LAFUMA, AND MARTHE PAVLOWSKY. *Céramique*, **39** [582] 179–89 (1936).—This method is based on the variation of the surface tension at the surface of separation of water and another unmixable liquid (when traces of alkalis are added to the aqueous solution); the surface tension is thus diminished. This phenomenon was employed for the study of changes produced in glass by water attack and is used to determine

the alteration produced by water in glazes. The effect of diluted acids could be determined. This method permits rapid measurements and delicate comparisons. M.V.C.

Alumino-magnesium batch in hand bottle making. S. Ya. Raf. *Keram. & Steklo*, **13** [1] 8–10 (1937).—R. describes attempts to change the composition of bottle glass, the difficulties encountered, and the results obtained. M.V.C.

Annealing glass in the Fourcault drawing chamber. A. I. Goderzov. *Keram. & Steklo*, **13** [2] 5–6 (1937).—Because of unsatisfactory results obtained when annealing glass in the Fourcault drawing chamber, a special type of leer was devised for uniform cooling of the glass band. M.V.C.

Annealing glass at lower temperatures. A. I. Stosharov and V. A. Florinskaya. *Optiko-Mekh. Prom.*, **6** [4] 3–7 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2657.—Glass plates of 5 x 5 x 1.5 cm. were cooled for a longer time under their normal annealing temperature and the decrease in stresses was studied. The temperatures were 400 and 330°; the samples annealed at the latter temperature were stored for a year. It was found that stresses decreased rapidly at first, then slower, and finally remained constant in spite of longer annealing. The glass tested lost 95% of its stresses at 400°, 25% at 330°, and only 5% at 230°. Two glasses annealed at different temperatures and different times but having the same stresses were again annealed together at 390°. Stresses in glass annealed at higher temperatures rapidly decreased, while those in glass annealed at lower temperatures but for a longer time remained practically unchanged. Conclusions are that the theory of Adams and Williamson has no general validity and that thicker glasses require higher temperatures of annealing. M.V.C.

Attempts to eliminate bubbles by means of gas-free glass. V. N. Verzner and M. A. Yur'ev. *Optiko-Mekh. Prom.*, **6** [8] 3–5 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2657.—To eliminate bubbles in glass difficult to refine, additions of glass degasified in a vacuum were made to the glass batch. The theory of the experiments is that gas bubbles represent a gas surplus undissolved in glass which will dissolve again in glass free from bubbles. Degasification of pulverized glass was performed in an electric furnace at from 10 to 30 mm. Hg pressure. The glass foamed very much, and the samples were degasified several times. The addition of up to 15% of this degasified glass to batches containing gas was useless. No decrease in the amount of bubbles was observed. M.V.C.

Beginnings of the plate glass industry in Belgium. Sainte-Marie d'Oignies plate glass factory. Joseph de Dorlodot. *Verre & Silicates Ind.*, **8** [5] 50–52; [6] 65–67; [7] 76–79; [8] 90–92; [9] 101–103; [10] 112–16; [11] 126–28; [12] 139–42 (1937).—The founding of the Société Anonyme Manufacture de Glace, Verres à Vitres, Cristaux et Gobeleteries (plate glass, window glass, crystal glass, and hollow glass) in 1836 was an important event in Belgian industrial history. Four glass manufacturing companies and one finance company combined under one administrative board to form the original company. A history of the founding and organization are given. In 1837 the plate glass factory of Sainte-Marie d'Oignies was built by this company. François Kemlin was instrumental in the establishment of the first plate glass factory in Belgium. M.V.C.

Bibliography on decolorizing of glass. Morris Schrero and F. C. Flint. *Bull. Amer. Ceram. Soc.*, **16** [6] 236–46 (1937).

Chemical resistance of glasses. Alix Cornille. *Céram., Verrerie, Email.*, **4** [1] 11–15 (1936).—Absolute inalterability of glass is a technical and scientific impossibility; therefore it is the relative inalterability of a glass, *i.e.*, inalterability under the particular conditions of use, which is important. Testing and control methods must differ according to the use of the glass. The action of pure water and alkaline, acid, and salt solutions on glasses is studied by the following, fully described, testing methods on glass powders (technical tests of the glass manufacturer) or on glass objects under the conditions of use (commercial and utilization tests): (1) The phenolphthalein test can be applied to ordinary glasses only in powder form but serves as a criterion of adequate quality. For most glasses in ordinary usage, their alkalinity is measurable by this process, although it is not suitable for neutral glasses destined for chemical, bacteriological, or physiological use. (2) The test with methyl red is more sensitive than the first and is used for ordinary glasses, in tests on whole vessels, and for neutral glasses in powder tests. (3) Tests with iodesine or erythrasine are very delicate and long and require precautions and corrections. (4) Tests with different solutions are used on special glasses. M.V.C.

Chemistry of colored glass: III. Woldemar Weyl. *Glass Ind.*, **18** [5] 167–71 (1937).—Dealing with the mutual interaction of coloring oxides of different valences with each other and with the oxides of arsenic, W. shows that in iron glasses MnO and CeO_2 act as decolorizers by shifting the iron equilibrium toward the ferric oxide side. It is shown that under normal melting conditions some oxides occur only as unstable compounds. The difficulty of the whole problem lies in establishing an absolute measure of the stability or instability of a given oxide and in the fact that the stability is affected by many factors. A series of relative stabilities is given. The discoloring effects of annealing and solarization are discussed. Possibilities of developing new colors are pointed out. For Part II see *Ceram. Abs.*, **16** [7] 201 (1937). E.J.V.

Coöperation of glass plants established for hand operation in technical scientific mutual work. Karl Hesse. *Glastech. Ber.*, **14** [5] 173–77 (1936).—Until recently there has been little or no coöperative operation among glass plants because of the difficulty of maintaining a laboratory and its personnel. A mechanization of plant operation almost always restricts the construction of a research laboratory and an investigation program because of the problems involved. A mechanization presupposes that, currently or in longer periods, one glass, in the same or in similar forms, will be manufactured. Each phase of production should be investigated and set up to the best advantage. Where there is a case of small output and a constantly changing form, the possibility of a mechanization and exact production lacking, research for the plant is almost always economically impossible. From the range and kind of questions in the so-called "question box" type of journal, one can recognize how great is the necessity

for most glass plants to emerge from obsolete, purely empirical methods of operation and how many difficulties are encountered in production. In general each glass expert knows how numerous and different are the problems occurring in the plants. Thus all glass plants, mechanized or not, have their demands on technology and science, and they will be ready for coöperation when research and science enter on their most apparent complaints and the adjustment between research and practice. G.R.S.

Copper ruby glass. IKUTARO SAWAI AND IKUZO KUBO. *Jour. Soc. Chem. Ind. Japan*, **40** [3] 89–90B (1937).—The dependence of depth of color on the heating temperature of copper ruby glass is studied. The change of color at low temperature appears with the change of form; the color disappears at the temperature at which the glass begins to flow. M.V.C.

Destruction of pot bodies by optical glass. V. VARGIN. *Optiko-Mekh. Prom.*, **6** [2] 3–9 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2427.—The attack of the melt on the walls of pots was studied by melting glass in small crucibles prepared from these pots in an electric furnace. The pot material contained an addition of 0.3% Co_2O_3 which corresponded to the amount dissolved by the glass and which permitted a colorimetric study of the attack. Blungers were made of the pot material and immersed into the molten glass. The glass attack was determined by the loss in weight of the pot, the amount of sesquioxides which passed into the glass, and the coloring produced by Co_2O_3. The glasses used were a heavy baryta crown glass, a heavy flint glass, and a borosilicate glass. Curves showing the glass attack have a break at 1200° for the baryta crown glass and at 1300° for the flint glass, possibly corresponding to the dissociation of silicates and borosilicates and the formation of free oxides and Pb and Ba. Chasov-yar clays are corroded more than Latnaya clays. Stirring the melt increases corrosion only with borosilicate glass and decreases it with baryta and crown glasses. M.V.C.

Determination of sulfate in the glass batch. M. A. FREZE AND N. A. FREZE. *Zavodskaya Lab.*, **5** [10] 1194–96 (1936).—The Blacher method is more rapid and convenient, requiring only 20 min. as compared with the Rashig and Tananaev methods which require 1 hr. P.B. & E.S.

Development of a new receipt for heavy baryta crown glass of the L.24 type. K. G. KUMANIN AND R. L. NEMIROVSKAYA. *Optiko-Mekh. Prom.*, **6** [6] 6–9 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 3386.—The chemical stability of heavy baryta crown glass can not be improved by the addition of TiO_2 as the latter affects dispersion. The replacement of BaO by CaO also changes dispersion and lowers chemical stability. A marked improvement is obtained by increasing the Al_2O_3 content, *e.g.*, in the following batch: 34.00% SiO_2, 8.4% B_2O_3, 7.4% Al_2O_3, 50.20% BaO, $n_p = 1.620$, $n_f - n_c = 0.01057$. M.V.C.

Developments and problems of liquid thermometry. W. GRUNDMANN. *Glas & Apparat*, **17** [6] 49–51; [7] 59–61; [8] 69–71; [9] 75–78; [16] 137–39; [17] 147–48; [18] 159–60; [19] 169–71; [20] 179–80; [24] 213–15; [25] 223–25 (1936); **18** [3] 21–22; [4] 33–34; [5] 43–44; [7] 65 (1937).—G. discusses thoroughly the history of thermometers and thermometry, materials used for the temperature indication, glasses and their composition, coloring matters, effect of the gases on the glass, precision thermometers, constancy and means for obtaining and maintaining it, design and construction, methods of manufacture, testing, and calibration. M.H.

Distribution of streaks and optical inhomogeneities in raw glass. A. I. STOSHAROV AND V. A. FLORINSKAYA. *Optiko-Mekh. Prom.*, **6** [5] 12–14 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2844.—Samples of optical glasses removed from a pot which was left to cool freely showed that streaks appear mostly near the bottom, walls, and surface and are affected often by thermal flows in the cooling glass. Inhomogeneities (excluding streaks), however, appear chiefly near the surface of the glass. M.V.C.

Effect of alumina on the surface tension of molten glass. C. W. PARMELEE AND C. G. HARMAN. *Jour. Amer. Ceram. Soc.*, **20** [7] 224–30 (1937).

Effect of steam and arsenic on the melting process of heavy baryta crown glass. V. V. VARGIN AND A. A. KEFELI. *Optiko-Mekh. Prom.*, **6** [1] 3–5 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2427–28.—The effect of steam on the melting batch consists in the promotion of the evaporation of B_2O_3 and thus it changes the composition of the glass. Under a normal pressure the formation of Ba borates, which are formed at low temperatures, and the formation of borosilicates at over 700°C are accelerated. As_2O_3, alone or in the presence of steam, accelerates the decomposition of $BaCO_3$, the dissolving of SiO_2, and the formation of borosilicates. The effect of As_2O_3 and steam is additive. The increase of temperature by 100°, however, accelerates the rate of melting of the glass to a much greater extent than the joint effect of steam and arsenic. M.V.C.

Electric-bulb manufacture in Japan. ANON. *Mitsubishi Econ. Research Bur., Monthly Circ.*, No. 161, 21 (March, 1937).—Electric bulbs were first manufactured in Japan in 1890. By 1911, sufficient progress had been made to meet the home demand. Since the World War, exports have been vastly in excess of imports. In 1936, exports numbered 314 million bulbs valued at 9.8 million yen; imports were 0.6 million yen. A large number of small factories employ not more than five workers; three-fourths of the total output is made by factories belonging to the Nihon Denkyu Kogyo Kumiai Rengo Kai. H.H.S.

Firing up of pots, floaters, and rings. F. H. ZSCHACKE. *Keram. Rundschau*, **44** [44] 527–29 (1936).—The removal of hygroscopic water at 100 to 110°C and of chemically bound water at 500 to 700°C must be reasonably slow. At other temperatures, the rise may be accelerated. The final firing of pots is attained in the melting oven where the first glazing (with cullet) is made at 1400°C or higher. This is not the case with floaters, boats, rings, etc., intended for tanks. The arching of pots requires only 1200°C and that of floaters 1400°C. Z. has devised firing charts for pots (3 days) and for tank refractories (6 days). The vitrification of ceramic bodies and the formation of bonded mullite require a long firing at 1300°C. Tank blocks must be fired a few hours at 1400°C or higher. F.E.V.

Fracture of glass plates by percussion. T. OKAYA AND K. ISHIGURO. *Proc. Phys.-Math. Soc. Japan*, **19,** 53–71 (Jan., 1937); abstracted in *Science Abs.*, **40** [472] 355

(1937).—A cylindrical weight with a needle point at the bottom of the axis was dropped from varying heights onto plates of glass 5 x 5 cm. and 2 and 3 mm. thick, and the forms of the percussion figures, in particular the radial fractures, were observed. The connection between the numbers and positions of such fractures and the percussion force as deduced from several hundred experiments is discussed with the aid of elaborate mathematics. Results seem to show that the number of such fractures is at first practically independent of the force, but tends finally to increase as it increases. H.K.R.

Glass wool. F. O. Anderegg. *Keram. Rundschau*, **44** [22] 255–57 (1936).—A. briefly describes the manufacturing processes of glass and rock wool and their use for insulation and air filtration. F.E.V.

Holophane glass and its use in U.S.S.R. A. I. Bogu-slavskiĭ and M. P. Sveshnikov. *Keram. & Steklo*, **13** [2] 13–17 (1937).—Principles of manufacturing holophane glass for illuminating purposes and its use are dealt with. M.V.C.

Manufacture of selenium ruby. V. V. Vargin. *Keram. & Steklo*, **13** [1] 16–23 (1937).—The chief stages in the production of selenium ruby and the effect of some factors on the quality of the glass are discussed. Red ruby glass may be colored by colloidal gold, colloidal copper, or colloidal compounds of CdS and CdSe. For technical purposes, especially signalization, the latter two glasses are used, as gold ruby glass is purple, being transparent to red and violet rays. From the light technical viewpoint colored glass is characterized by the spectrum curve of absorption or permeability. Characteristic curves of copper and selenium ruby are given and show that copper ruby has a greater "density" in the red part of the spectrum and its absorption curve is much less steep. Se ruby is especially good for the production of pressed articles of various thicknesses, but Cu ruby can not be used. Se ruby can give different colors by changing the amount of Se and CdS, the composition of the glass, and the conditions of melting; thus light yellow, orange, red, dark red, and "infra-red" (glasses permeable to thermal rays and absorbing visible rays) glasses can be produced. The character of the curve of spectral absorption does not depend on the amount of Se and CdS used. However, the slope of the curve of absorption or its steepness may be changed. Experiments showed that lime potassium glasses can not be used for Se ruby. Red rubies with a transparency of 610 to 620 $\mu\mu$ and a steep slope of 0.5 can be produced with soda-lime glasses; their color tone is stable but they are sensitive to the conditions of melting. Zinc glasses were found to be the most suitable for obtaining red ruby; the danger of opacification and burning out of the pigments is lowered and the steepness of the curve of absorption increases. In glasses of mixed types, lime-potassium-soda, lime-zinc-soda, and others, absorption depends chiefly on the amount of oxide present. The concentration of pigments in selenium ruby is of great importance. V. concluded that (1) the limit of absorption which characterizes color does not depend on the absolute amount of Se and CdS but on the ratio of Se to Cd, (2) the steepness of the curve of absorption does not depend on the Se content but on the CdS content only; the greater the CdS content, the steeper is the curve. The conditions of melting and working selenium ruby are discussed in detail. M.V.C.

Memorial to Karl Scheel. Anon. *Glastech. Ber.*, **14** [11] 409–10 (1936). G.R.S.

Modern electric melting furnaces. W. Jaekel. *Chem. App.*, **24** [6] 81–85 (1937).—J. describes recent developments in resistance, electric-arc, and induction furnaces and their constructional details and fields of application. M.H.

Rapid modified method of analysis of soda-lime glass. Michel B. Vilensky. *Bull. Amer. Ceram. Soc.*, **16** [6] 234–36 (1937).

Rôle of surface stresses during refining when melting glass. A. A. Appen. *Optiko-Mekh. Prom.*, **6** [5] 5–12 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 2656–57.—Sugar syrup was used for the experiments and the effect of the addition of A, ether, and isoamyl alcohol on the disappearance of bubbles was studied. These were obtained by mixing equal parts of syrup with Na_2CO_3 solution or HCl and stirring for a long time. Lowering the surface stresses accelerates greatly its refining; isoamyl alcohol and ether were the most effective. The effect of a series of heavy oxides or alkali sulfates and alkali halogenides on surface stresses of a glass of the composition $Na_2O \cdot 2SiO_2$ was studied. The additions correspond to the formula $Na_2O \cdot 2SiO_2 + 0.06R_m O_n$, M_2SO_4, or MHal. It was found that Cr_2O_3 and alkali sulfates are the best in lowering glass stresses in the series $Na_2SO_4 - K_2SO_4 - Cs_2SO_4$. A comprehensive discussion of the theory of the effect of refining agents is given. Their effect is accounted for by the lowering of surface stresses and because they possess a high steam tension in solution. These properties promote a rapid growth and a uniting of the originally small bubbles. M.V.C.

Secrets of Italian glassmakers in the Middle Ages. W. Ganzenmüller. *Glashütte*, **67** [15] 247–50; [16] 260–61 (1937).—G. describes the raw materials, their working and melting, and the types of glasses manufactured in the Middle Ages in Italy. The compositions of various types of glasses and a literature index are given. M.V.C.

Seeds in opal casing glass. G. Körrn. *Keram. Rundschau*, **44** [27] 315–16 (1936).—Seeds are frequent in opal glass. K. describes defects due to incorrect melting or working, *i.e.*, gall, white, iron, and gathering seeds. During casing, dirt due to contact of organic matters causes seedy glass. F.E.V.

Series of glasses colored by sulfurous matter: II–III. F. Fuwa. *Jour. Soc. Chem. Ind. Japan*, **40** [2] 64–65B (1937).—Over 0.02% sulfur was necessary to give the glasses a yellowish orange color. Zinc sulfide gives an orange-yellow color, iron sulfide gives a bluish color, and sodium sulfide gives no yellow color, probably because the sulfur is decomposed by its crystalline water in the course of melting. For Part I see *Ceram. Abs.*, **16** [6] 171 (1937). M.V.C.

Silica lining for hydrochloric reaction apparatus. I. Ya. Klinov and D. I. Sychev. *Khim. Mashinostroenie*, **5** [6] 33–36 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 3375.—Plates of fused diabase were found to be the best material for linings of apparatus resistant to HCl. Powdered diabase with 10% asbestite is used as cement. M.V.C.

Specifications for lead glass in Czechoslovakia. V.

CTYROKY AND M. FANDERLIK. *Glass Ind.*, **17** [12] 415–16 (1936).—From analyses and tests on various lead glasses, the following standard specifications were arrived at: (1) For the designation "Bohemian lead crystal" the following values for lead crystal glass are specified: minimum lead oxide content 20.0%, minimum refractive index for sodium light 1.530, minimum relative dispersiveness 0.020, and minimum specific gravity 2.78. (2) For semi-lead glass designated as "Bohemian lead glass," the following values are specified: minimum lead oxide content 9%, minimum refractive index for sodium light 1.519, minimum relative dispersiveness 0.017, and minimum specific gravity of 2.56. (3) For glass material for the manufacture of "Gablonz goods" and gem imitation, only specifications for the optical properties characterizing the general appearance of the product and the specific gravity will be devised. E.J.V.

Striae in safety glass. T. PESCH. *Glashütte*, **67** [11] 189–90 (1937).—Striae occur in safety glass because of (1) excessive dissolving of the intermediate layer in the bath, (2) too long drying, (3) too high temperature during pressing, and (4) the opening of the "sandwich." In some cases these waves disappear in the course of 3 to 5 days. In the majority of cases, however, a heat treatment is required with renewed pressing at a higher temperature, raised by 7 to 12°. M.V.C.

Studies on reactions between glasses and phosphate solutions. J. B. BROWN AND ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **20** [7] 245–50 (1937).

Supposed glassblowers in pre-Roman Egypt (12th dynasty, about B.C. 1900). PAUL DIEGART. *Glastech. Ber.*, **14** [11] 422–23 (1936).—Egyptian carvings instead of representing a glassblower with a blowpipe depict a worker using a metal pipe to heat metal in the furnace. The lump on the end of the pipe is clay to protect the tube and keep it from becoming too hot to handle. G.R.S.

Surface strains of melted soda and lead glasses. A. A. APPEN. *Optiko-Mekh. Prom.*, **6** [3] 7–12 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2428.—The surface strains of Na_2O-SiO_2 and PbO-SiO_2 glasses were determined by the method of the weight of drops. Important for the exactness of the method is the length of time in which the separate drops are formed. Rapidly formed drops have too high a weight. The minimum weight of drops of highly viscous glasses is reached after several hours, *e.g.*, for the glass $79SiO_2 \cdot 21Na_2O$ it takes from 7 to 10 hr. The surface strains of soda glasses with 49.8 to 79.4 SiO_2 and their temperature coefficients are in linear dependence on their composition; increased Na_2O content increases the surface strain. It amounts to 283 or 298 dynes/cm. at 1200°C in these glasses. PbO-SiO_2 glasses (with from 0 to 61.5% SiO_2) behave in the same way. PbO lowers surface strain. It amounts to from 124 to 220 dynes/cm. at 900° for this glass series. On the points of the curve composition-surface strain, which correspond to the known crystalline compounds of Na_2O or PbO and SiO_2, no breaks were found. It is unknown whether this fact can be used as proof of the nonexistence of these compounds in molten glasses or is due to the indifference of surface strains to the formation of such compounds. M.V.C.

Use of lattices for the detection of streaks in optical glasses. R. N. RAUTIAN. *Optiko-Mekh. Prom.*, **6** [1] 11–12 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 2431. M.V.C.

Vinyl resin for safety glass. HERBERT CHASE. *Brit. Plastics*, **8** [85] 5–7 (1936).—A serious defect of all laminated glass is its relatively high brittleness at low temperatures. At 0°F all forms shatter easily. At 60°F both acetate and nitrate sheets are strong. Shortcomings in respect to brittleness were a primary consideration leading to the development of the new form of vinyl sheet, and a remarkable degree of toughness was secured. At normal temperatures, it has rubber-like toughness and, though losing some of this toughness at low temperatures, glass made with it is not punctured by a half-pound steel ball falling from a 30 ft. height, even at temperatures of −10°F. Nitrate and acrylate laminated glass withstand an impact from only one tenth this height. The properties of this new plastic and the glass made from it are given. G.R.S.

X-ray investigation of the glassy state. N. VALENKOV AND E. PORAY-KOSHITZ. *Z. Krist.*, **95,** 195–229 (1936).—The two contrasting hypotheses of glassy structures, *i.e.*, the hypothesis of continuous noncrystalline atomic network and the crystallite hypothesis, are discussed. X-ray powder patterns were made of specimens of crystalline and vitreous SiO_2 and of soda-silica glasses with varying compositions which had been subjected to varying thermal treatments. Experimental X-ray scattering curves obtained by microphotometric measurements of X-ray photographs are found to be in good agreement with theoretical curves based on presence of crystallites in glass varying from 7.5 to 25 Å. in size. Soda-silica glasses were found to consist of metasilicate crystallites as well as low-temperature cristobalite. See *Ceram. Abs.*, **15** [6] 193 (1936). H.I.

BOOK

Finishing Hollow or Flat Glass (Die Veredlung des Hohl und Flachglases). MANDER. Glashütte, Dresden. 280 pp., 150 illustrations. Price 6.80 Rm. Reviewed in *Verre & Silicates Ind.*, **8** [11] 135 (1937).—This book is a sequel to the manual of Springer treating the production of unfinished glass. It is a valuable aid and reference for practical and theoretical teaching. All methods of finishing glass are explained clearly and simply enough for pupils without scientific background to understand. Technical and artistic considerations are emphasized. The descriptive chapters and those treating the cutting, etching, and painting of glass are capably treated. Springer explains the cementation of hollow glasses, iridescence, and acid etching. Zschacke describes the working of flat glasses, polishing by grinding and sanding, frosting, acid etching and rendering the surface mat, silvering, painting, and improvement of safety glasses. M.V.C.

PATENTS

Air-filter framework. F. L. MYERS AND H. V. SMITH (Owens-Illinois Glass Co.). Can. 363,574, Jan. 19, 1937 (April 6, 1936). G.M.H.

Apparatus for:

Forming glassware. K. E. PEILER AND A. J. SMITH

(Hartford-Empire Co.). U. S. 2,081,859, May 25, 1937 (Oct. 13, 1932).

Forming hollow glass articles. H. A. WADMAN (Hartford-Empire Co.). U. S. 2,084,285, June 15, 1937 (July 3, 1935).

Forming hollow glassware. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,081,858, May 25, 1937 (Sept. 22, 1934).

Indicating and controlling temperatures in glassmelting tanks. H. W. MCINTOSH (Hartford-Empire Co.). U. S. 2,081,595, May 25, 1937 (Sept. 24, 1935).

Producing laminate glass. W. C. BULL. U. S. 2,084,293, June 15, 1937 (Feb. 19, 1932).

Tempering glass. AMERICAN SECURIT CO. Brit. 466,037, June 2, 1937 (Dec. 4, 1934).

Automatic machine for shaping the ends of glass tubes. J. DICHTER. Brit. 465,888, June 2, 1937 (Nov. 15, 1934).

Automatic sealing of ampoules. F. PIAK. Ger. 637,943, Oct. 15, 1936 (March 5, 1935); P 70,897, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [84] 115A (1937). In a process for sealing ampoules in which they are sent down a straight line track and subjected to the action of flat sharp flames, while rotated about their axes, the ampoules are held between a traveling belt and a stationary plate so that they engage the latter and rotate their ends in the flame sweeping across the space above the track.

Debiteuse for drawing sheet glass. VEREINIGTE VOPELIUSSCHE UND WENTZELSCHE GLASHÜTTEN A.-G. Ger. 636,474, Sept. 17, 1936 (July 31, 1935); V 32,028, VI/32*a*, Gp. 23_{II}; *Jour. Soc. Glass Tech.*, **21** [84] 117A (1937).—The glass is fed to the slit of the debiteuse through an opening in the long side of the latter.

Delivering molten glass to rolls. A.-G. FÜR GLASINDUSTRIE VORM F. SIEMENS. Ger. 636,473, Sept. 17, 1936 (Feb. 20, 1935); A 75,362, VI/32*a*, Gp. 19; *Jour. Soc. Glass Tech.*, **21** [84] 117A (1937).—In a process for rolling sheets of glass in which a stream of the molten material flows from a furnace over a lip into a trough from where it overflows onto the surface of a roller, the trough is so mounted that the pouring lip is capable of being moved to and fro to keep it in correct relation to the roller.

Denture. F. M. LOTT (Corning Glass Works). Can. 364,300, Feb. 23, 1937 (May 31, 1935). G.M.H.

Edge-grinding machine. V. H. GOTTSCHALK (Pittsburgh Plate Glass Co.). U. S. 2,084,138, June 15, 1937 (Oct. 31, 1936).

Electric lamp. H. D. BLAKE AND W. J. GEIGER (Canadian General Electric Co., Ltd.), Can. 364,282, Feb. 23, 1937 (July 15, 1933). W. J. GEIGER (Canadian General Electric Co., Ltd.), Can. 364,284, Feb. 23, 1937 (Nov. 29, 1933). W. J. GEIGER AND A. T. GASKILL (Canadian General Electric Co., Ltd.), Can. 363,334, Jan. 12, 1937 (Feb. 27, 1935). ANTONIUS DE GRAAFF (Canadian General Electric Co., Ltd.), Can. 364,139, Feb. 16, 1937 (March 8, 1933). ADOLF JASTROW, ALFRED SITTEL, AND HANS WOLFF (Canadian General Electric Co., Ltd.), Can. 364,148, Feb. 16, 1937 (June 16, 1933). G.M.H.

Electric lamp and mounting. J. T. FAGAN, J. F. DONOVAN, AND F. J. MALLOY (Canadian General Electric Company, Ltd.). Can. 363,478, Jan. 19, 1937 (April 18, 1934). G.M.H.

Enameled article. W. W. SHAVER (Corning Glass Works). Can. 364,337, Feb. 23, 1937 (Dec. 19, 1935). G.M.H.

Feeding rolled glass sheets to the leer. PILKINGTON BROS., LTD. Ger. 635,804, Sept. 10, 1936 (March 15, 1935); P 70,944, VI/32*a*, Gp. 34; *Jour. Soc. Glass Tech.*, **21** [84] 117A (1937). Addition to Ger. 629,149 (*Ceram. Abs.*, **16** [6] 172 (1937)).

Glass beveling machine. F. W. O. WERNICKE AND B. R. MULLER (trading as Wernicke & Co. Machinenfabrik). Brit. 465,465, May 20, 1937 (Nov. 1, 1935).

Glass feeder. G. R. HAUB (Shawkee Mfg. Co.). U. S. 2,083,152, June 8, 1937 (June 1, 1932).

Glass-forming machine. A. AFTERGUT. Ger. 637,025, Oct. 10, 1936 (Dec. 29, 1934); A 74,937, VI/32*a*, Gp. 15; *Jour. Soc. Glass Tech.*, **21** [84] 113A (1937).—The machine has a blow mold and a parison mold equipment adapted to work by the suction feeder (or press) process or by a combination of these.

Glass-forming machine. T. C. MOORSHEAD (Ball Brothers Co.). U. S. 2,081,895, May 25, 1937 (Nov. 28, 1936).

Glass-grinding machine. K. A. WEBER. Can. 363,297, Jan. 5, 1937 (Oct. 15, 1935). G.M.H.

Glass percolator top. W. B. MOORE AND JUSTIN K. WAHL. Can. 363,261, Jan. 5, 1937 (Jan. 3, 1936). G.M.H.

Glass-shaping apparatus. C. A. BROWN AND C. E. HAHN (Canadian General Electric Company, Ltd.). Can. 363,151, Jan. 5, 1937 (July 25, 1934). G.M.H.

Glass sheet casehardening apparatus. G. R. FORD, JR. (American Securit Co.). Can. 363,870, Feb. 2, 1937 (March 30, 1936). G.M.H.

Glass strip producing apparatus. F. B. WALDRON (Pilking Bros., Ltd.). Can. 363,894, Feb. 2, 1937 (Feb. 6, 1936). G.M.H.

Glow lamp. P. J. KAYATT (International Glow Lamp Corp.). Can. 363,396, Jan. 12, 1937 (Sept. 3, 1935). G.M.H.

Incandescent lamp. E. C. SMALLY. Can. 363,642, Jan. 26, 1937 (April 30, 1935). G.M.H.

Increasing luminescence of inorganic glasses. GLASWERKE G. FISCHER. Ger. 607,090, Oct. 15, 1936 (May 9, 1932); G 82,615, VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, **21** [84] 95A (1937).—Zinc, calcium, and strontium or barium sulfide are added to the glass together with compounds of heavy metals such as manganese, copper, bismuth, thallium, lead, antimony, cadmium, tungsten, or rubidium, the concentration of these heavy metals being so chosen that they must take part in the formation of the phosphorescent material in the glass. Ger. 636,630, Oct. 15, 1936 (June 9, 1933); G 85,726, VI/32*b*, Gp. 2; addition to Ger. 607,090. This covers the addition of sulfates, borates, silicates, phosphates, or fluorides of heavy metals such as zinc, calcium, strontium, or barium which themselves form phosphorescent material. Ger. 617,148, Oct. 15, 1936 (June 8, 1933); G 85,716, VI/32*b*, Gp. 2. The compounds of the rare earth elements are used as activators in place of those of the heavy metals named in the present specification. Ger. 636,747, Oct. 15, 1936; G 85,047, VI/32*b*, Gp. 2; addition to Ger. 607,090. The process described in the parent specifi-

cation is modified to include the use of sulfides of magnesium, beryllium, or aluminium as phosphorescent bodies.

Insulator. C. H. DIBBLE (Corning Glass Works). Can. 363,495, Jan. 19, 1937 (April 9, 1934). G.M.H.

Insulator having high surface resistance and method of making it. W. W. SHAVER (Corning Glass Works). U. S. 2,081,508, May 25, 1937 (May 2, 1934). An insulator having a glass surface, an area of which is stained with a metal of the group consisting of copper and silver, the stained area having a higher electrical resistance than the unstained area.

Laminated glass. CAMILLE DREYFUS. Can. 363,783, Feb. 2, 1937 (July 31, 1929). ADOLF KAMPFER. Can. 364,376, Feb. 23, 1937 (Jan. 4, 1935). J. F. WALSH (Celluloid Corp.). Can. 363,823, Feb. 2, 1937 (Nov. 18, 1929). G.M.H.

Laminated nonsplintering glass. W. D. SPENCER (Canadian Industries, Ltd.). Can. 363,655, Jan. 26, 1937 (Dec. 24, 1934). G.M.H.

Light-spreading lens. W. A. DOREY AND T. W. ROLPH (Holophane Co., Inc.). U. S. 2,082,100, June 1, 1937 (Sept. 7, 1933).

Machine for producing hollow glass articles. C. C. KINKER (Owens-Illinois Glass Co.). U. S. 2,082,639, June 1, 1937 (Dec. 7, 1934). U. S. 2,082,640, June 1, 1937 (April 15, 1935).

Making glass hollow ware with metal inserts. P. ROSENKAIMER. Ger. 637,831, Oct. 15, 1937 (Feb. 26, 1934); R 90,014, VI/32*a*, Gp. 22; *Jour. Soc. Glass Tech.*, **21** [84] 115A (1937). The metal portions are placed in the mold, fluid glass is dropped in, and the mold is rotated so that the glass lines the surface and engages the metal parts.

Manufacture of glass tubing. M. REINHARDT GEB. DÖHLER. Ger. 632,580, June 18, 1936 (May 13, 1935); R 93,330, VI/32*a*, Gp. 24_{m}; *Jour. Soc. Glass Tech.*, **21** [84] 114A (1937).—A small cylindrical blank with central hollow space closed at one end is affixed to a blowing iron and then placed in the desired position in a surrounding mold, and the intervening space is filled with molten glass. From the parison so produced the glass tubing is drawn.

Means for forming glass bottles, jars, etc. T. F. PEARSON. Brit. 464,929, May 13, 1937 (Nov. 21, 1935).

Means for opening and closing the molds of a machine for forming glassware. T. F. PEARSON. Brit. 464,930, May 13, 1937 (Nov. 21, 1935).

Melting glass in sealed enclosure. SENDLINGER OPTISCHE GLASWERKE G.M.B.H. Ger. 636,475, Sept. 17, 1936 (Jan. 26, 1935); S 112,633, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [84] 83A (1937).—The working chamber is filled with an inert or a combustible gas, and the flames are produced at the melting station by narrow burner openings.

Method of annealing glass-to-metal seals. WESTINGHOUSE ELECTRIC & MFG. CO. Brit. 465,931, June 2, 1937 (Oct. 15, 1935).

Method and apparatus for forming hollow glass articles. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,081,857, May 25, 1937 (April 24, 1934).

Method and apparatus for handling and emptying glass-melting pots. H. E. ROBINSON AND F. C. EICHER (Libbey-Owens-Ford Glass Co.). U. S. 2,081,769, May 25, 1937 (May 4, 1934).

Method and automatic apparatus for coating bottle necks. E. T. FERNGREN (Fernplas Corp.). U. S. 2,081,478, May 25, 1937 (Sept. 11, 1934).

Method of producing glass containers. C. B. GARWOOD (Carr-Lowrey Glass Co.). U. S. 2,082,695, June 1, 1937 (May 4, 1935).

Method and product for treating glass wool. R. C. WILLIAMS AND H. M. BONE (Owens-Illinois Glass Co.). U. S. 2,083,132, June 8, 1937 (July 30, 1934; renewed Oct. 16, 1936). (1) As a new article of manufacture, glass wool fibers coated with a film deposited from an emulsion of oil and water, the film so deposited being in an amount which adequately lubricates the fibers but is insufficient to propagate flame at the normal ignition temperature of the oil. (3) The process of treating glass wool strands comprises the steps of applying to the strands, while they are heated at a temperature constituting a fire hazard with hydrocarbon oil, a dilute hydrocarbon lubricant emulsion in water which will not support combustion at the temperature of treatment and then removing the water to produce a residual film upon the strands.

Molding machines for glassware or other articles made from molten material which sets on cooling. T. F. PEARSON. Brit. 466,117, June 2, 1937 (Nov. 20, 1935).

Pen for writing on glass. P. FICHTMÜLLER. Ger. 637,944, Oct. 15, 1936 (March 18, 1936); F 80,898, VI/32*b*, Gp. 6_{30}; *Jour. Soc. Glass Tech.*, **21** [84] 121A (1937).—The prepared pen is dipped into a "solution" containing equal parts of water and fluorspar, and after drying, the writing is fumed into the glass by heating at temperatures up to 700°, according to the composition of the latter.

Plant for simultaneous production of drawn sheet and cast plate glass. DRAMMENS GLASSVERK. Ger. 636,583, Sept. 24, 1936 (Oct. 22, 1934); D 68,971, VI/32*a*, Gp. 1; *Jour. Soc. Glass Tech.*, **21** [84] 117A (1937).—The melting end of a tank furnace provided with at least one continuous drawing machine also feeds a separately heated working compartment from which glass is taken for casting.

Process and apparatus for making safety glass. J. H. SHERTS (Duplate Corp.). U. S. 2,084,113, June 15, 1937 (March 23, 1935).

Processing of skeletonized borosilicate glass. H. P. HOOD AND M. E. NORDBERG (Corning Glass Works). Can. 364,157, Feb. 16, 1937 (Feb. 14, 1935). G.M.H.

Production of glass tubes. M. REINHARDT GEB. DÖHLER. Ger. 637,753, Oct. 15, 1936 (July 6, 1935); R 93,728, VI/32*a*, Gp. 24_{m}; *Jour. Soc. Glass Tech.*, **21** [84] 114A (1937). Addition to Ger. 632,580 ("Manufacture of glass tubing," this page). In a process for making tubing according to the parent specification by building up a composite gather around the blowpipe which is placed in a mold for the purpose, the blowpipe is held in position by a stand or guide member.

Production of transparent silica ware. CORNING GLASS WORKS. Ger. 638,955, Nov. 5, 1936 (July 19, 1935); C 50,749, VI/32*a*, Gp. 35; *Jour. Soc. Glass Tech.*, **21** [84] 97A (1937).—A hydrolyzable silicon compound is introduced into a gas flame so that the vapor is decomposed

to form very finely divided silica which fuses to a transparent mass.

Refractory glass. G. F. ADAMS (Canadian General Electric Co., Ltd.). Can. 363,333, Jan. 12, 1937 (Jan. 30, 1935). G.M.H.

Removing caps from blown hollow ware. A. MEDER. Ger. 632,885, June 25, 1936 (Aug. 14, 1930); B 150,639, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [84] 115A (1937).—A melting-off and edge-finishing machine is described.

Skimming surface of glass in suction forehearth. T. F. PEARSON. Ger. 638,665, Oct. 29, 1936 (May 20, 1935); P 71,124, VI/32*a*, Gp. 5; *Jour. Soc. Glass Tech.*, **21** [84] 111A (1937). See Brit. 438,850 (*Ceram. Abs.*, **15** [2] 62 (1936)).

Ultra-violet transmitting glass. CORNING GLASS WORKS. Ger. 637,438, Oct. 8, 1936 (Oct. 13, 1928); C 42,060, VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, **21** [94] 95A (1937). —This provides for the use of carbonaceous matter in a batch containing only traces of iron and titanium oxides which is melted under reducing conditions. Zinc oxide is added to offset the yellow tinge imparted by the excess reducing materials used.

Ultra-violet transmitting glass. I. G. FARBENINDUSTRIE A.-G. Ger. 634,698, Aug. 13, 1936 (May 20, 1931); I 41,629, VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, **21** [84] 95A (1937). Addition to Ger. 633,269 (*Ceram. Abs.*, **16** [6] 173 (1937)).—The composition of the parent specification is modified to include aluminium metaphosphate. Ger. 634,699, Aug. 13, 1936 (Nov. 27); I 43,121, VI/32*b*, Gp. 2. This covers the introduction of Ca and/or Mg metaphosphates in amount approximately equal to that of the Ba salt in the batch. Ger. 636,035, Sept. 10, 1936 (Aug. 11, 1932); I 45,091, VI/32*b*, Gp. 2; addition to Ger. 634,699. In addition to phosphates of Ca, Mg, and Ba claimed in the previous specifications, the present one provides for the inclusion of aluminium metaphosphate.

Vehicle headlight. V. J. ROPER (Canadian General Electric Co., Ltd.). Can. 363,649, Jan. 26, 1937 (Nov. 2, 1932). G.M.H.

Vitreous material and method of manufacture. P. K. DEVERS (Canadian General Electric Co., Ltd.). Can. 364,288, Feb. 23, 1937 (Jan. 30, 1935). This is an insulating composition with essentially the properties of fused silica but with improved workability when plastic and with less brittleness, consisting mainly of silica and containing beryllium oxide and/or alumina.

G.M.H.

Structural Clay Products

Action of lime on dehydrated kaolin. GIOVANNI MALQUORI AND FRANCESCO SASSO. *Ricerca Sci.*, [2] **8**, I [3–4] 144–47 (1937).—Further investigations on the attack of lime on dehydrated kaolin at 650 to 700° showed that the marked cement-like action of dehydrated kaolin at 650 to 700° is caused by reactions between the lime, silica, and alumina of the product of the thermal disintegration of kaolinite with the formation of compounds of the same type as those which originate in the hydration of clinkers. See *Ceram. Abs.*, **15** [10] 300 (1936). M.V.C.

Cellular clay materials. ANON. *Corriere Ceram.*, **18** [3] 75 (1937).—Cellular clay materials are made by (1) the addition to the clay of a certain per cent of material, such as andalusite or kyanite ($Al_2O_3 \cdot SiO_2$), which, when heated, expands and forms gases which escape, leaving air spaces; (2) introduction of a gas which forms bubbles; (3) use of infusorial or diatomaceous earth; and (4) firing clay in which carboniferous matter has been added, the most common method. These porous materials have a weight 25% of that of similar materials of compact structure. Regarding thermal conductivity, 1 hr. and 10 min. are required for a porous wall 1.2 m. thick to reach 120°C, and only 35 min. are needed for an ordinary brick wall to reach the same temperature. As to acoustical insulation, these materials absorb 80% of the sound at a frequency of 1.024. The resistance to crushing of these materials varies inversely with their weight per volumetric unit. The smaller the cells, the more resistant they are. M.V.C.

Pipes for house drainage. J. N. C. MCTAGGART. *Clay Prod. Jour. Australia*, **4** [7] 14–15 (1937).—After 40 years' experience in the use of pipes of all materials, McT. is in favor of prohibiting the use of concrete pipe in house drainage. The Sydney Board has under its control stoneware pipes which were laid down 100 years ago and are as good today as if just made. If concrete sewers are used, it is necessary to line them with stoneware to protect them. H.H.S.

Use of salt to lower the freezing temperature of green brick. B. M. GRISSIK AND M. I. LAPOVOK. *Stroitel. Materialy*, No. 12, pp. 8–11 (1936).—The amount of the optimal addition depends on the lowest temperature to which the brick is exposed. The calculation can be made as follows: $\frac{0.06\,MGW}{100 + W}$ kg. NaCl for 1000 brick, where M = necessary concentration of salt in g./mol./liter of water, G = weight of 1 brick, and W = moisture content of the mass. Salt has no marked effect on the drying properties of clay. An addition of a considerable amount of salt influences negatively the physicomechanical properties of clay and the outer appearance of the brick. P.B. & E.S.

STANDARD AND BOOKS

Clay Facing and Backing Brick. British Standard Specification No. 657—1936. BRITISH STANDARDS INST., London. The standard size for brick in the British Isles is $8^3/_4$ x $4^3/_{16}$ x either $2^3/_8$ or $2^7/_8$ in. with a tolerance of $^1/_8$ in. in the length and $^1/_{16}$ in. in width or thickness. The measurements are made not on a single brick but on eight brick laid end-to-end, side-by-side flat, or side-by-side on edge. The specification deals only with the dimensions named. A.B.S.

Report of the Building Research Board for 1935. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. H. M. Stationery Office, London, 1936. 176 pp. Price 3s 6d. Clay building materials are discussed on pp. 60–65. An attempt was made to correlate the results of physical and chemical tests with the performance on exposure of clay building materials. The resistance to sodium sulfate

crystallization increased as the firing temperature increased, and for most clays firing at 1050°C gave a product sufficiently resistant for all ordinary building requirements. In general, the relative resistance of different fired clays to the crystallization test can not be predicted from a consideration of their saturation coefficients or porosities. The florescence test is used as a guide to the liability of the various brick to effloresce, and the soluble-salt analyses have been examined to discover whether the content of one of the constituents shown by the analysis is correlated with liability to effloresce. Liability to effloresce is in no way proportional to total soluble-salt content, because the greater part of the soluble matter found in brick consists of calcium sulfate which is relatively inert from a florescence point of view, though it may be a source of other troubles. Consideration of the separate constituents in the analyses shows that there is good correlation between the content of soluble magnesium compounds and the liability to effloresce, a conclusion which is in accordance with experience, in that magnesium sulfate is nearly always the destructive agent in cases of serious florescence failure. The alkali content shows no correlation with liability to effloresce, and a part, at least, of the alkalis found in the soluble-salt analyses is derived from the unavoidable decomposition of silicates by water during the extraction of the powdered sample and not from soluble salts. Results available for a wide range of English brick show that the soluble-salts content may range from 0.1% to as high as 4.0%. The relations between crushing strength and weather resistance have shown some interesting conclusions. Handmade brick generally have good weathering qualities, but as a class they are much weaker than machine-made brick. Among the machine-made brick, those of high strength (over 7000 lb./in.^{2}) have been little affected by exposure in the soil, while all those of strength less than 5000 lb./in.^{2} showed some degree of failure. There are, however, brick of good and poor performance in the range of 5000 to 7000 lb./in.^{2}. H.E.SIMPSON

Rudimentary Treatise on the Manufacture of Bricks and Tiles. A. B. SEARLE. Technical Press, Ltd., London, 1936. 14th ed. This little book was begun by the late Edward Dobson but revised and altered from time to time and now largely rewritten by S. It is still the most descriptive book dealing with the manufacture of handmade brick and tile in the English language. The book especially meets the requirements of those who live remote from large towns and who wish to produce brick or tile in outputs of 1 to 3 million per year with a minimum of machinery and capital expenditure. Such works can not compete with the much larger, highly mechanized works, but there is ample scope for small works in many parts of the British Empire and in some parts of the U. S. For these, and as a good yet fairly brief introduction to the subject of brick and tile manufacture (chiefly as carried out in the British Isles) this book serves a useful purpose, as shown by the fact that probably no other book on brick and tile manufacture has passed through fourteen editions. A.B.S.

PATENTS

Argillaceous material firing apparatus. F. W. BUTTERWORTH AND I. R. CLINE (Western Brick Co.). Can. 363,900, Feb. 2, 1937 (Jan. 20, 1936). G.M.H.

Brick veneering structure. H. J. NACHREINER. U. S. 2,081,380, May 25, 1937 (Sept. 16, 1936).

Building block. H. J. KAUFMAN. Can. 364,237, Feb. 16, 1937 (Jan. 28, 1936). A. L. SCUDDER. Can. 364,383, Feb. 23, 1937 (Jan. 31, 1936). G.M.H.

Building block and building wall construction. L. S. MUNSON. Can. 364,244, Feb. 16, 1937 (Jan. 28, 1936). G.M.H.

Interlocking building block. AQUILINO MARTINICHIO. U. S. 2,082,457, June 1, 1937 (June 23, 1936).

Method of making an expanded ceramic product. F. W. BUTTERWORTH, I. N. DOUGHTY, AND I. R. CLINE (Western Brick Co.). Can. 363,899, Feb. 2, 1937 (Jan. 20, 1936). G.M.H.

Treatment of masonry wall surfaces. W. F. WELLS (William Grund). U. S. 2,082,193, June 1, 1937 (Jan. 13, 1934). The method of providing a waterproof protective covering for porous masonry surfaces comprises applying to the surface a filling and a hardening composition including cement and pulverized oxidizable metal as ingredients, forcing the composition into the pores of the masonry surface to fill it, allowing the composition to harden partially, removing substantially all of the surplus composition, maintaining the composition in a dampened state to hasten the oxidation of the metal, and applying a coating of penetrating waterproof wax composition to the outer surface of the first-mentioned composition when the metal therein begins to oxidize to prevent further oxidation thereof and render the covering for the masonry surface impervious to moisture.

Refractories

Adsorption of lime from solutions by quartzites. S. L. HERMAN. *Ukrain. Khem. Zhur.*, **12** [2] 77–86 (1937).—Both hard and soft quartzites are capable of adsorbing lime from solutions at a rate depending on their structure, porosity, and fineness of grind. When working up silica masses with pans, the adsorption increases. The interaction of lime with quartzite powder evidently possesses the character of a chemical reaction. The adsorption isotherms, when plotted logarithmically, have the shape of straight lines, *i.e.*, the process can be quantitatively expressed by the Freundlich rule. P.B. & E.S.

Casting pit refractories. A. MCKENDRICK. *Refrac. Jour.*, **13** [2] 63 (1937).—A study of the refractories used in casting pits necessarily involves a knowledge of the carbon content of steel melted in contact with the refractories. High carbon steels are less erosive than low carbon steels. M. outlines procedures for producing and selecting the most satisfactory grade of casting pit refractories. The firing of these refractories is perhaps the most important step in their production for it is in this operation that the desired texture, quality, size, and shape are determined. Rammed ladles have been used with varying

degrees of success, depending upon the ramming mix used and the procedure and care used in lining the ladle. M.C.S.

Chemical analysis of silicon carbide and silicon carbide refractories. ANON. *Zavodskaya Lab.*, **5** [10] 1191–94 (1936).—Silicon carbide can be best decomposed by fusing together with a mixture of Na_2CO_3 (97.5%) and KNO_3 (2.5%). The total carbon content can best be determined by calcination with metaline lead in an oxygen current. The graphite content can be determined by calcination in an electrical furnace at 1000° in an air current. P.B. & E.S.

Choice of a rational curve for reheating the roof of open-hearth furnaces. N. LOZINSKIĬ AND A. ZHURBENKO. *Stal*, **6** [10] 33–48 (1936).—The roof of open-hearth furnaces is covered by silica brick, a refractory which requires a particular attention in the reheating process of the roof. The authors discuss various crystalline modifications of silica brick and the deformation of roofs by reheating. Because the roof of the furnace is deformed, for the greater part, before the beginning of fusion of the metal, various authors such as Smelyanskiĭ, Shvetzov, and others have proposed different temperature curves for reheating these roofs. Heat flow is calculated, and a description and analysis of the temperature curve of Smelyanskiĭ, which differs from others by a very slow rise in temperature, are given. A reheating curve for roofs of open-hearth furnaces at the Ilyich metallurgical works (Sartana, U.S.S.R.), the volume change of brick by reheating, the advancement of the area of $\beta \rightarrow \alpha$ transformations, and the choice of a rational reheating curve are discussed. This study has established the following conditions, which guarantee the highest durability of the open-hearth furnace roofs: (1) primary drying and reheating of the furnace to 230°C should be conducted with a rate of temperature rise inside the furnace of about 7 to 8°C/hr.; (2) further rise in temperature from 230 to 575° should be carried out in the limits of 10°C/hr.; (3) from 575 to 1600°C, a rise of the roof temperature inside the furnace at a rate of 30 to 40°C/hr. and a following increase of 50 to 60°C are permissible (there must, however, be no decrease in the already attained temperature of the roof); and (4) the total time necessary to reheat the furnace is evaluated at 82 to 84 hr. In general, the temperature curve of reheating the roofs of open-hearth furnaces appears as a smoothly rising curve with a slow rise of the temperature of the roof to 575°C and a rapid increase of temperature during the following hours. B.E.K.

Development of modern metal melting furnaces. J. TROSTMANN AND F. WALTER. *Siemens-Z.*, **17** [1] 18–28 (1937).—A description is given of construction and properties of the different types of melting furnaces, with special regard to the advantages of induction furnaces and of the materials used in them. Low-frequency induction furnaces are now preferably used for melting Cu, Cu alloys, Zn, and, recently, light metals. The lining of these furnaces is discussed in detail; the following mixture is recommended for melting of brass: SiO_2 56.85, Al_2O_3 31.47, Fe_2O_3 3.59, sulfur oxide 2.87, lime 0.9, traces of magnesia, and other volatile materials 3.40%. About 2000 melts can be made with this lining, while about 800 melts of pure Cu or Cu-Ni alloys can be made with it. The consumption for Cu-Zn alloys amounts to about 190 kw.-hr./ton, and for Zn 97 kw.-hr. When melting Al, the formation of gas in the molten metal due to presence of water must be prevented, as H is soluble in the melt and O forms undesirable precipitations on the bottom. M.H.

Development and recent progress of the special refractories industry in France. DANIEL PETIT. *Céramique*, **39** [584] 211–17 (1936).—The manufacture of compressed refractories showed definitely the advantages of silico-aluminous brick, which for a time were replaced by silica brick for coke ovens; the inherent qualities of the products were united without the defects of either. Bauxite products are also greatly improved by compression although they are used mostly in coke furnaces, and magnesia products successfully compete with them. Sillimanite products support very high temperatures and are durable. Corundum brick have not been improved lately owing to their cost. The same is true of silicon carbide whose characteristics of hardness, impact strength, and conductivity permit its use in various types of furnaces, such as muffles, retorts, recuperators, etc. Magnesia products are used successfully in glass furnaces in Germany although their manufacture is complicated by the careful selection of appropriate raw materials. Magnesia brick combined with chromium are used in metallurgy. Of the various refractory linings, siliceous, argillaceous, and compound linings mainly are used; the latter contain hardening agents. Zirconium brick have not yet been developed. M.V.C.

Genefax House. ANON. *Metal Ind.* [London], **49** [14] 351 (1936).—Genefax House, administrative quarters of General Refractories, Ltd., was opened in Sept., 1936. The growth and successful development of the company from its foundation as The Kelham Island Firebrick Company in 1913 to the present time is commented upon. H.E.S.

Grog-quartz refractory brick. P. P. BUDNIKOV AND S. A. ZHIKHAREVICH. *Ukrain. Khem. Zhur.*, **12** [2] 91–94 (1937).—The composition of the charge for quartz-grog refractory brick is as follows: Kondratyevka sand with grains under 2 mm. 60 to 70, Mikhaylovka quartzites with grains under 0.2 mm. 10, grog from Kirovo clay with grains under 1 mm. 20, and binding clay (Kirovo and Druzhkovka) 10%. The brick was fired at 1450° and had the following properties: beginning of deformation under load of 2 kg./cm.^{2} 1440 to 1500°, 4% at 1470 to 1520°, 10% at 1550°; refractoriness, P.C.E. 31 to 32; mechanical strength about 95.5 kg./cm.^{2} The authors believe that the problem of obtaining grog-quartz brick with an increased deformation temperature has been solved by them; further investigations are necessary in order to increase the mechanical strength without lowering the refractoriness. P.B. & E.S.

Insulation of open-hearth steel furnaces. A. E. DODD. *Refrac. Jour.*, **12** [12] 669 (1936).—In a résumé of the use of insulation on open-hearth steel furnaces, D. concludes that when insulation is properly applied there is normally (1) a fuel savings, (2) a longer refractories life, and (3) better and more positive temperature control. M.C.S.

Korundiz, a new high-grade ceramic material. L. J. KATZ AND G. L. EFREMOV. *Zadovskaya Lab.*, **5** [10] 1274–75 (1936).—The material is obtained by using alu-

mina as the fundamental raw material transformed into corundum crystals. The ware is prepared by casting and firing to complete sintering in electrical and oil furnaces at about 1700°. The sintering is made possible by adding 1 to 2% of alkaline earth salts or other mineralizers facilitating the formation of crystals at lower temperatures. The material is used for preparing high-refractory crucibles, electric furnace tubes, and thermocouple tubes. It has a high resistance to alkalis. P.B. & E.S.

Manufacture of dolomite brick. A. V. TERESHCHENKO AND O. M. MARGULIS. *Zitein Tesco*, No. 2268, 6 pp. (1936); abstracted in *Referat. Silikatliteratur*, **4** [3] 3841 (1937).—Crushed raw dolomite with additions of open-hearth slag was mixed, shaped, and fired to 1650°C. The fired mix was ground and 4% linseed oil added. The mix was treated according to the semidry method, pressed, dried for 3 days, and fired to 1450°C in an oxidizing atmosphere. The brick obtained had a refractoriness of over cone 40 (1920°C), a resistance to pressure of 4.5 kg./sq. cm. at 1410° and 2 kg./sq. cm. at 1500°, a water absorption of 6.5, a porosity of 18.3, a specific gravity of 2.75, and a hardness of 6.5%. M.V.C.

Manufacture of refractory products with a carbon base. ANDRÉ CARLIER. *Céramique*, **39** [577] 69–73 (1936).—This article is based on a study made in Germany and published by Tonind.-Zeitung in 1935, and deals with (1) raw materials, (2) bond, (3) working of the mix, (4) drying, (5) firing, and (6) properties. M.V.C.

Minerals used in refractories. ANON. *Refrac. Jour.*, **12** [12] 707 (1936).—Cordierite is a silicate of aluminum, iron, and magnesium with water ($4(Mg, Fe)O4Al_2O_3$-$10SiO_2H_2O$). This mineral has a melting point of cone 16 and when heated somewhat above 1400°C, it decomposes with the formation of spinel and mullite. M.C.S.

Need for classification and grading of fire brick. J. W. WRIGHT. *Refrac. Jour.*, **13** [2] 103 (1937).—Great Britain, exclusive of Scotland, has no classification or grading of fire brick. Scotland recently classified its refractories into three classes, A, B, and C, the A grade rating being the highest and most expensive. M.C.S.

Producing hollow and perforated silicate brick and blocks with Bernhardy and Buckau R. Wolf presses. M. YA. SAPOZHNIKOV. *Stroitel. Materialy*, No. 2, pp. 14–17 (1937). P.B. & E.S.

Properties required of checker brick, testing methods, and physical and chemical investigations. R. V. WIDEMANN. *Céramique*, **39** [585] 235–41 (1936).—W. reviews specifications of checker brick with special regard to volume stability, resistance to temperature fluctuations, increased thermal conductivity, smooth surface to avoid deposition of dust, and resistance to mechanical strains. Silicoaluminous refractories with a low alumina and flux content should be the most suitable. A homogeneous distribution of iron oxide in the brick is of the utmost importance. Various testing methods used to determine the properties of these brick are discussed in detail. M.V.C.

Refractory material. ANON. *Refrac. Jour.*, **12** [11] 617 (1936).—Molochite, a china clay calcined at 1600°C, is now produced as a highly refractory material containing 43.27% alumina. It has a P.C.E. of 35, and X-ray examination shows a high mullite content. This material is at present used in the manufacture of certain high-grade refractories. M.C.S.

Refractory minerals. Spinel. S. I. PERKAL. *Refrac. Jour.*, **12** [8] 427 (1936).—Spinel is the term used to designate (1) the $MgO{\cdot}Al_2O_3$, (2) a compound corresponding approximately to the formula $RO{\cdot}R_2O_3$, with the RO group usually composed of one of the oxides BaO, BeO, CuO, FeO, MgO, MnO, NiO, or ZnO and the R_2O_3 composed of Al_2O_3, Fe_2O_3, Cr_2O_3, and (3) a scarlet ruby-like precious stone. M.C.S.

Report of General Refractories, Ltd., for 1936. FRANK S. RUSSELL. *Electrician*, **118** [3070] 473 (1937).—The following three new types of brick are discussed: (1) Saxpyre, for use in basic open-hearth furnaces; (2) Spinnella, made of magnesia, chromite, and alumina; and (3) Dolomax brick, a basic brick almost entirely of English dolomite. H.K.R.

Requirements of silica brick for coke ovens. A. KORA. *Jour. Fuel Soc. Japan*, **16**, 1–4 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 3201.—A table of desirable and undesirable properties of silica brick used in coke ovens is given and discussed in detail. With respect to chemical composition, silica brick must contain as much tridymite as possible. Fe_2O_3 content should be between 1.5 and 3.0%. A content of up to 1.5% Al_2O_3 is permissible. In small brick of simple shape, the CaO content may reach 2.5%; in large brick, it may be 3.5%. Density must be below 2.35%; porosity should lie between 22 and 28%. The minimum strength is 180 kg./sq. cm. The softening temperature with a load of 2 kg./sq. cm. must lie between 1500 and 1600°C. With respect to thermal expansion, the latter may be lowered by a suitable composition, firing temperature, and firing time. However, a temporary expansion of 1.2% and a permanent one of 0.5 or 0.7% is unavoidable. The total expansion should lie between 1.35 and 1.5%. When estimating silica brick for coke ovens, the separate properties should not be taken into account alone; the combination of the chemical and physical properties should also be considered. M.V.C.

Sillimanite and kyanite in Western Australia. E. S. SIMPSON. *Jour. Roy. Soc. W. Australia*, **22**, 1–18 (1936).—An abundant supply of microspicular sillimanite 0.01 to 0.10 mm. in diameter is found at Toodyay. At Clackline, where fire brick has been made for 30 years, the greater part of the clay is a kaolinized biotite-sillimanite schist, in the sillimanite concentrates of which are found kyanite crystals. H.H.S.

Slag tapping of flat-bottom boiler furnaces. J. H. STRASSBURGER. *Mech. Eng.*, **57** [6] 367–68 (1935).—The construction of four types of furnace bottoms is described and illustrated. The most effective bottom from the standpoint of both service and cost consisted of one course of 9-in. fireclay brick laid on end with 6 in. of plastic chrome ore on top of the brick. F.G.H.

Theoretical and experimental studies of the crushing of refractory products under load on firing. PIERRE BREMOND. *Céramique*, **40** [586] 1–10; [587] 21–28; [588] 41–44; [589] 61–66 (1937).—The comparative study of testing apparatus of Méker, Dupuy, Long, and Petit showed inconclusive results. B. studied the furnace atmosphere, chemical reaction of this atmosphere, viscosity of refractories as a function of temperature and atmos-

phere, effect of the rate of firing, the variation of the structure of refractories during crushing, and the effect of their size and composition. M.V.C.

Thermal conductivity in relation to crystal structure. W. A. Wooster. *Z. Krist.*, **95**, 138–49 (1936).—Crystals for which both structures and conductivity anisotropies are known have been divided into three groups. To group I, containing crystals for which the bonds are not of markedly differing strengths in different directions, a theory of conductivity anisotropy is applied which gives approximately the correct value for the 5 crystals tried. Crystals in group II, with layer lattices, show greater conductivity along the layers than normal to them. Crystals in group III (the chain lattice type) have greater conductivity along the chains than normal to them. H.I.

Thermochemistry of metallurgical dolomite and utilization of its deposits in the Donetz basin for the production of lining material for steel-melting furnaces. K. F. Mukhin. *Ukrain. Khem. Zhur.*, **11** [6] 466 (1936); **12** [1] 1–16 (1937).—Artificial dolomite mixtures can be used to produce stable metallurgical dolomite only if they contain 5 to 9% silica. Sesquioxides have no independent stabilizing importance, but a minimum content of 2% is necessary for the interaction of lime and silica during the firing process. Firing at the necessary temperature is effective only if the dolomites have the necessary chemical composition. The minimum temperature for the sintering of chemically stable dolomites is 1560°. P.B. & E.S.

PATENTS

Baffle for heat-exchange tubes. J. C. Woodson (Lee Wilson). U. S. 2,081,612, May 25, 1937 (Nov. 13, 1936). A baffle for heat-exchange tubes comprises a plurality of refractory blocks, an axial hole through each block, and a metallic link positioned in the hole in each block, the links having a head at one end and an eye at the other adapted to receive the head of an adjacent link, whereby the links may be assembled in a chain with the blocks strung on the links in the manner of beads.

Clinker-brick refractories. L. T. Work. U. S. 2,083,180, June 8, 1937 (Sept. 12, 1935). The process of making refractory articles comprises admixing with refractory aggregate a fluid bonding agent including water-glass and a calcium compound which is reactive with water-glass to produce a calcium silicate bond containing a material amount of tricalcium silicate and having a higher fusion temperature than the temperature of reaction of water-glass and the compound, and forming the mixture into shapes.

Converter. T. S. Curtis. U. S. 2,065,566, Dec. 29, 1936 (June 14, 1935). A converter for heat treatment of refractory materials, etc., comprises a combustion compartment having a charging opening at its upper portion and a discharge opening at its lower end, and including side walls, a cover for the charging opening and a discharge door for the discharge opening, a plurality of tuyères in the side walls of the compartment for conducting fuel thereto, the tuyères being disposed one above the other to admit fuel to the compartment in superposed zones thereof, and fuel-supply means for the tuyères for varying the amount of fuel supplied to the tuyères to the extent that less fuel is supplied to an upper tuyère than to a lower tuyère in proportion to the preheating effect of the lower combustion zone on the superposed zone.

Furnace bridge wall. Alexander Hynd. U. S. 2,083,846, June 15, 1937 (Aug. 17, 1934).

Furnace lining. Joseph Karmanocky. U. S. 2,082,698, June 1, 1937 (Oct. 1, 1935).

Furnace for treating vermiculite. G. C. Wright and Honeywill and Stein, Ltd. Can. 363,254, Jan. 5, 1937 (Aug. 27, 1935). G.M.H.

Furnace-wall construction. P. W. Antill (American Arch Co.). U. S. 2,081,417, May 25, 1937 (July 17, 1933). For a sectionally-supported multiblock wall, a metallic hanger member comprises a vertically elongated main body portion, means adjacent the upper end thereof formed to hangingly engage a support, and means adjacent the lower end thereof formed to provide a laterally open recess for embracingly engaging a wall block.

Furnace-wall construction. G. M. Slaughter and G. W. Black (Athens Brick & Tile Co.). U. S. 2,084,225, June 15, 1937 (Dec. 3, 1936).

High-temperature refractory cement. G. E. Seil (E. J. Lavino & Co.). U. S. 20,413, June 15, 1937 (Jan. 30, 1937); reissue of original 2,042,363 (*Ceram. Abs.*, **15** [8] 245 (1936)). A cement material for refractory uses comprises essentially heat-treated recrystallized chromite, sodium silicate, and periclase.

Magnesite-chrome-olivine refractory. F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). Can. 363,991, Feb. 9, 1937 (July 24, 1935). G.M.H.

Manufacture of cementitious insulating compositions from vermiculite. P. S. Denning (F. E. Schundler & Co., Inc., and Illinois Clay Products Co.). U. S. 2,084,276, June 15, 1937 (April 2, 1935). The method of making a cementitious insulating material is characterized by exfoliating granules of vermiculite and floating the exfoliated granules upon a solution of magnesium sulfate to allow heavy impurities to sink, skimming off the floating vermiculite granules, draining off excess solution from the granules, adding magnesium oxide and enough additional magnesium sulfate solution to bring the total magnesium sulfate solution, including that adhering to the granules, to such proportion relative to the magnesium oxide to form magnesium oxysulfate cement, then mixing all the materials together, and molding them.

Method of producing a concentrate of chrome ores. Gustav Arnold (Eduard von Orelli). U. S. 2,082,817, June 8, 1937 (May 8, 1934).

Process for the manufacture of magnesium or alloys thereof. D. Gardner. Brit. 465,623, May 26, 1937 (Dec. 23, 1935).

Production of alumina practically free from silicic acid from alkaline earth aluminates. Lonza Elektrizitätswerke und Chemische Fabriken A.-G. Brit. 465,644, May 26, 1937 (April 20, 1935).

Production of alumina substantially free from silicic acid from alkaline earth aluminates. Josef Stöhr and Erich Reidt (Lonza Elektrizitätswerke und Chemische Fabriken A.-G.). U. S. 2,082,526, June 1, 1937 (April 10, 1936). In a process for the production of alumina practically free from silicic acid by lixiviation of alkaline

earth aluminate containing silicic acid soluble in alkali carbonate with a solution of alkali carbonate, separation of the alkali metal aluminate solution from the undissolved residue, and precipitation of the alumina, the step consists in subjecting the alkaline earth aluminate before lixiviation to an oxidation treatment with an oxygen-containing gas at raised temperature.

Production of magnesium from dolomitic ores. D. GARDNER. Brit. 465,622, May 26, 1937 (Dec. 23, 1935).

Refractory. KARL HACKS AND W. S. SPROW (Roy E. Cook and Joseph G. Cooper). Can. 363,252, Jan. 5, 1937 (Nov. 7, 1935). The method consists of fusing a refractory lining on an interior surface of a furnace, comprising application of a layer of a mixture of granular refractory and particles of a readily oxidizable metal and the oxidizing of the metal of the mixture to supply heat for fusing the refractory. G.M.H.

Refractory insulation. O. L. JONES (Illinois Clay Products Co. and F. E. Schundler & Co., Inc.). U. S. 2,081,935, June 1, 1937 (July 9, 1934). The method of making a refractory cement is characterized by bonding together particles of exfoliated vermiculite with a magnesium oxysulfate cement, firing one face of the bonded material at temperatures exceeding 2000°F to decompose the surface layer of cement at the face, while preventing substantial penetration of heat into the body of the material to prevent decomposition of the latter, increasing the temperatures to develop a ceramic bond in place of the decomposed cement, and, during the formation of bond, supporting the surface layer by the unaltered body of the material.

Refractory material, method of improving basic or neutral refractories containing silica as a deleterious constituent, and method of manufacturing refractory materials. N. P. PITT, A. C. HALFERDAHL, AND F. E. LATHE. Can. 363,778, Feb. 2, 1937 (Oct. 17, 1934). G.M.H.

Refractory product and process for its manufacture. C. J. BROCKBANK AND SOC. D'ÉLECTRO-CHIMIE, D' ÉLECTROMÉTALLURGIE, ET DES ACIÉRIES ELECTRIQUES D'UGINE. Brit. 465,313, May 20, 1937 (April 18, 1935).

Tuyère. GORDON FOX AND O. R. RICE (Freyn Engineering Co.). U. S. 2,082,280, June 1, 1937 (May 1, 1935).

Terra Cotta

Defects of stoneware tile; their causes and effects. FELIX CHALAMEL. *Céramique*, **39** [579] 109–19 (1936).—The principal defects of fired tile (they can be applied to all ceramic products) are enumerated and classified into (1) structural defects and (2) commercial defects. The minimum values of stoneware tile are porosity, 2.5%, crushing, 1400 kg./sq. cm., and wear, 4 mm. The physical and chemical characteristics permit the differentiation between stoneware and semi-stoneware or ordinary terra cotta tile. Tables showing physical and chemical characteristics of these products are given. These properties show the nature of the products. Commercial defects are numerous and vary according to whether they affect the surface or appearance and whether they are due to raw materials, their working, shaping, composition, drying, and firing, or carelessness. M.V.C.

Enriching architectural forms by ceramics. L. DAMM. *Tonind.-Ztg.*, **61** [9] 105–109 (1937).—Modern trends in the use of terra cotta ornamentation, tile facings, and other ceramic products for business houses, residences, and public buildings are examined, and good taste and poor taste in ornamentation are illustrated. M.V.C.

Flat tile: drying and firing. ANON. *Argile*, No. 167, pp. 17–19; No. 168, pp. 5–7 (1937); see *Ceram. Abs.*, **16** [5] 153 (1937). M.V.C.

Stoneware *versus* cement pipes. H. G. WILLS. *Clay Prod. Jour. Australia*, **4** [6] 21 (1937).—From his experience as superintendent of house drainage under the Sydney Metropolitan Board, W. believes that house drains should be constructed of stoneware and acid-resisting joints. H.H.S.

PATENTS

Acidproof tank. RICHARD NEUHAUS (Nukem Products Corp.). U. S. 2,083,469, June 8, 1937 (July 15, 1935).

Heat-insulation material. H. W. GREIDER (Philip Carey Mfg. Co.). Can. 364,187, Feb. 16, 1937 (Jan. 31, 1936).—The material contains basic magnesium carbonate, precipitated calcium carbonate, bentonite, diatomite, asbestos fiber, and amphibole fiber. G.M.H.

Sound absorbing article and method of manufacture. E. R. POWELL (Johns-Manville Corp.). Can. 363,881, Feb. 2, 1937 (Jan. 24, 1936). This material consists of sound-permeable clusters of heat-resistant fibers bonded and faced by ceramic material. G.M.H.

Thermal conductivity cell unit. W. J. WILLENBORG (U. S. Fire Protection Corp.). Can. 363,246, Jan. 5, 1937 (Jan. 31, 1936). G.M.H.

Tiling. M. T. BENNETT. U. S. 2,082,241, June 1, 1937 (Feb. 23, 1933). In a structure of the character described, a base member having spaced-apart parallel grooves therein, a tile having a flange thereon for entrance in one groove, a second flange for entrance in a spaced groove, one of the flanges being resilient and having means for coöperation with a wall of its groove for securing the tile on the base member.

Wall tile packing and unpacking method. H. S. MCELROY (Franklin Tile Co.). Can. 363,393, Jan. 12, 1937 (Jan. 30, 1936). G.M.H.

Whiteware

Andalusite in porcelain bodies. O. A. RADVL'CHUK. *Keram. & Steklo*, **13** [1] 23–29 (1937).—Andalusite porcelain mixes are easily worked, pressed, shaped, or cast. Andalusite lowers the shrinkage on firing of porcelain bodies, and they should be fired at higher temperatures than those without it. The porosity of andalusite bodies is generally lower, but it increases with increased andalusite content. The mechanical strength of bodies con-

taining andalusite is considerably increased; when 30% is added to the mix, its mechanical strength increases 72%. The coefficient of expansion of the mix increases with the introduction of andalusite. Thermal resistance of andalusite bodies is, however, considerably lower than that of high-grade technical porcelain, especially when cast. Acid stability is lowered. Andalusite porcelain is green or gray when cast. Refractoriness is considerably higher. Andalusite can not be used for ware subjected to severe temperature fluctuations. Andalusite porcelain ware is affected by corroding gases and acids but is excellent where high mechanical strength is required. When replacing quartz or sand in technical porcelain, andalusite will improve all the properties of the porcelain. M.V.C.

Classification of ceramic dinnerware. ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **16** [6] 246–47 (1937).

Effect of sulfur on glazed ware. A. GALLASCH. *Ziegelwelt*, **68**, 1–3 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 2232.—When ancient glazed tile, etc., are compared with those manufactured at present, the former show a considerably greater durability which is accounted for by the fact that wood free from sulfur was used as fuel, while today coal containing sulfur is generally used for firing ware. Clay free from sulfur must be used to obtain durable glazes; water containing S is to be avoided. In general, all glaze constituents should be free from it as well as the coal used. The articles should be fired intensely to prevent efflorescences and weathering. At high temperature the SiO_2 of the body expels sulfuric acid according to the equation $CaSO_4 + SiO_2 = CaSiO_3 + SO_3$. In the same way silica destroys sulfuric acid combined with magnesia and alkalis. M.V.C.

"Five-and-Ten" china. ANON. *Ind. Gas*, **15** [9] 16 (1937).—A large manufacturer of china for the chain stores has reduced the labor required in forming and handling the ware. Drying is done in ovens using the waste heat from the kilns. Firing was formerly accomplished in 11 beehive kilns, but a continuous gas-fired tunnel-type kiln is now employed for both bisque and glost firing. Two double-chambered gas-fired beehive kilns are used for firing the decorated ware. S.S.

Insulating materials and their use. ERWIN BAYER. *Gummi-Ztg.*, **51**, 119–20 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 3536.—The properties and application of the chief insulating materials are dealt with. M.V.C.

Porcelain manufactured from Hungarian raw materials. LÁSZLÓ MATTYASOVSZKY. *Magyar Chem. Folyóirat*, **42**, 153-62 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 3386–87.—Experiments showed that the following raw materials are well suited for the manufacture of porcelain ware: (1) rhyolite kaolin from Sárospatak (humidity 0.35, loss on ignition 8.58, SiO_2 65.69, Al_2O_3 23.41, Fe_2O_3 0.19, TiO_2 0.11, CaO 0.28, MgO 0.81, K_2O and Na_2O 0.28, and SO_3 0.22) and its slip residue (0.20 moisture, 2.50 loss on ignition, 89.28 SiO_2, 7.26 Al_2O_3, traces of MgO and CaO, 0.12 Fe_2O_3, 0.06 TiO_2, and 0.49 K_2O and Na_2O); (2) rhyolite kaolin from Füzérradvány (2.74 moisture, 5.52 loss on ignition, 52.42 SiO_2, 28.25 Al_2O_3, 0.65 CaO, 2.47 MgO, 6.62 K_2O, 0.30 Na_2O, 0.07 TiO_2, and 0.15 Fe_2O_3); (3) quartz sandstone from Kővágóörs; and (4) clay from Pettény. M.V.C.

Porcelain pipe conduits. ANON. *Chem.-Ztg.*, **61** [4] 58 (1937).—Hard porcelain conduits are easily manufactured. Their special advantages are excellent appearance, smooth and glazed surface, high chemical resistance, and good resistance to temperature fluctuations. M.V.C.

Problems of the chinaware industry. FELIX SINGER. *Céramique*, **39** [575] 21–26 (1936).—The composition of porcelain ware and its effect on the various physical properties of chinaware are discussed in detail. M.V.C.

Relation between the properties of the slip and method of its working. YA. SHERMAN AND D. SLIVKO. *Keram. & Steklo*, **13** [2] 24–28 (1937).—Methods used for the preparation of slip are described in detail. Experiments showed that (1) methods used to prepare the slip have no effect on shrinkage or drying or firing of the mix; (2) ware made from pressed slip have a somewhat greater water absorption than those made from unpressed slip (this difference amounted to about 2% in plates fired to cone 8); and (3) the method of slip working has no effect on the mechanical strength. M.V.C.

PATENTS

Bushing insulator. T. F. BRANDT (Ohio Brass Co.). U. S. 2,082,046, June 1, 1937 (Sept. 24, 1935). RALPH HIGGINS (Ohio Brass Co.). U. S. 2,082,055, June 1, 1937 (March 27, 1936).

Electrical insulator and method of manufacture. F. H. RIDDLE (Champion Spark Plug Co.). Can. 363,699, Jan. 26, 1937 (Oct. 8, 1935). G.M.H.

Facing tile. A. GAUCHE. Brit. 465,001, May 13, 1937 (April 16, 1935).

Lavatory basins. F. P. BARBER AND OATES & GREEN, LTD. Brit. 465,680, May 26, 1937 (Feb. 20, 1936).

Method and apparatus for testing high-potential insulation. SIEMENS & HALSKE A.-G. Brit. 465,761, May 26, 1937 (March 15, 1935).

Spark plug. BREEZE CORPORATIONS, INC. Brit. 465,425, May 20, 1937 (June 12, 1935).

Spark plug core. A. J. HOPKINS. Can. 363,928, Feb. 2, 1937 (Sept. 16, 1935). G.M.H.

Equipment and Apparatus

Analysis of the work of presses for producing silicate brick of the Bernhardy, Dorsten, and Buckau R. Wolf works. M. YA. SAPOZHNIKOV. *Stroitel. Materialy*, No. 1, pp. 4–18 (1937). P.B. & E.S.

Apparatus for "optical" demonstration of some geometrical features of electron diffraction photographs. W. G. BURGERS AND J. J. A. PLOOS VAN AMSTEL. *Z. Krist.*, **95**, 54–73 (1936). H.I.

Aspiration psychrometer. A. F. SPILHAUS. *Trans. Roy. Soc. S. Africa*, **24** [3] 185–202 (1937).—The effect of radiation and of short-period fluctuations of temperature is to render the ordinary humidity measurers inaccurate. A compensated psychrometer is described, in which ventilation for the dry bulb is different from that of the wet bulb, thereby enabling accurate observations to be taken in spite of wide fluctuations of temperature. H.H.S.

Classification of permitted explosives: I. W. PAYMAN. *Colliery Eng.*, **14** [1] 21 (1937).—The permitted explosives used in mines and quarries belong to the high-explosive type, and the main ingredient is either nitroglycerine, ammonium nitrate, or mixtures of these. In the chemical classification these three groups may be subdivided into sections containing explosives characterized by the ingredients. In Group I are the nitroglycerine explosives which contain no ammonium nitrate. They are plastic gelatins containing approximately 60% nitroglycerine, and their high rate of detonation makes them valuable in stone drift or in very hard rippings. Group II includes the ammonium nitrate explosives which contain no nitroglycerine but which contain trinitrotoluene or trinitronaphthalene as sensitizing agents. Under Group II, Section 1 explosives contain 50 to 70% ammonium nitrate sensitized with trinitrotoluene; Section 2 explosives contain 35% ammonium nitrate sensitized with trinitrotoluene; and Section 3 explosives are ammonium nitrate sensitized with trinitronaphthalene. **II.** *Ibid.* [2] 40.—Group III explosives contain both nitroglycerine and ammonium nitrate. The subgroups or sections are based upon the nitroglycerine content: (1) explosives with 25% nitroglycerine, (2) explosives with 8 to 15% nitroglycerine, and (3) explosives which have low densities to reduce the shattering effect of the explosive. P.E.G.

Cutting knives of aërodynamic form for working clays. ANON. *Corriere Ceram.*, **18** [3] 82–85 (1937).—The curved form of the aërodynamic blades assures more complete mixing and advances the clay without temperature increase and with less motor power. The pressure this type of blade exercises on the mix improves plasticity and accelerates the expulsion of the occluded gases, such as carbonic acid, ethane, and methane, which are always present in clays as a result of the fermentation and distillation of organic matter deposited at the same time as the clays. See *Ceram. Abs.*, **14** [4] 97–98 (1935). M.V.C.

Deferrizing sands. M. A. LIFSHITZ. *Keram. & Steklo*, **13** [1] 10–11 (1937).—A method of washing sands on moving tables is described. The results are satisfactory. M.V.C.

Determination of the moisture content of green brick by routine method. ANON. *Zavodskaya Lab.*, **5** [10] 1225–26 (1936).—An electrical device based on the change of electrical conductivity in dependence on the moisture content is described. P.B. & E.S.

Dry-pressing brick with the Boyde press. M. I. LAPOVOK AND B. M. GRISSIK. *Stroitel. Materialy*, No. 1, pp. 18–26 (1937). P.B. & E.S.

Dust collector. HERMAN VAN TONGEREN. *Mech. Eng.*, **57** [12] 753–59 (1935).—The principles governing the design and operation of a dust collector for the dry extraction of dust are presented. Illustrated. F.G.H.

Fan forecasting. H. R. PHELPS. *Power*, **79** [4] 195 (1935).—P. briefly considers the factors which determine the performance of a fan operating under conditions considerably different from those specified in performance curves furnished when the fan was purchased. F.G.H.

Forgeability of light alloys. A. PORTEVIN AND P. G. BASTIEN. *Metal Ind.* [London], **49** [12] 296–300 (1936).—The optimum conditions for hot working of light alloys were determined. The authors indicate the important part played by the rate of deformation and show that the bending test apppears to be the most convenient, speedy, and sensitive test. Magnesium alloys can be extruded up to about 15% copper and 9% aluminum and can be forged, with care, up to about 15% copper and 7 to 8% aluminum. Aluminum alloys that contain 12% copper should be able to be extruded and forged with care; while for those containing magnesium, the limit of forgeability must lie between 5 and 10% magnesium. H.E.S.

Influence of service conditions on metal components of industrial plant. J. N. GREENWOOD. *Jour. Soc. Chem. Ind. Victoria*, **36**, 1174–81 (1936).—Of physical conditions, stress is the most important, and whether the stress is steady or fluctuating and at what temperature. The chemical conditions include temperature, electrochemical influence on corrosion, etc., and the nature of the surrounding medium. The structure of the metal, the size and shape of its crystals, the distribution of phases, and the presence of irregularities are the factors which govern the breakdown or cohesion of metal. H.H.S.

Integration of the drying equation at constant temperature. A. E. MARKHAM. *Ind. Eng. Chem.*, **29** [6] 641–42 (1937). F.G.H.

Jar-ramming molding machine. MOLINEUX. *Metal Ind.* [London], **49** [20] 489–90 (1936).—A new type of jar ramming molding machine is based upon a new method of ramming, in which a weight is caused to rest upon the loose sand of the mold during its consolidation by the jarring of the table. Illustrated. H.E.S.

Measurements of the shearing modulus of vitreous systems within the softening range. M. P. VOLAROVICH, B. V. DERYAGIN, AND A. A. LEONTIEVA. *Zhur. Fiz. Khim.*, **8** [4] 479–85 (1936).—An apparatus based on the principle of tortional vibrations of a rod has been designed for investigating the elasticity of melts at the moment of solidification at temperatures under 200°. The authors suggest that the temperature characterizes the moment of transition of highly viscous liquids to the solid amorphous state. P.B. & E.S.

Mining, crushing, mixing, and preparation of clay. W. NEIMANN. *Tonind.-Ztg.*, **61** [8] 83–87; [9] 111–14 (1937).—N. gives a detailed account of the proper extracting and working methods for different types of clays. M.V.C.

Sandblasting machines. ALFRED GUTMANN A.-G. *Metal Ind.* [London], **49** [15] 360 (1936).—The new Gutmann centrifugal machine of the rotating-table type is described in which the sand, instead of being forced on the work by compressed air, is projected by a centrifugal impeller. An ordinary centrifugal impeller projects the sand or shot onto the table or other flat surface in a narrow band about 6 in. wide, the length of the band depending upon the distance of the table from the outlet thrower. In the Gutmann machine, however, this impeller is also arranged to rotate horizontally about its own axis, in consequence of which horizontal movement of the surface covered by the sand covers a large circle. The abrasive is fed to the impeller from both sides so as to give a more effective distribution. There are no bucket elevators for returning the used abrasive to the hopper at the top of the machine, this being effected by the suction created by the impeller wheel itself. H.E.S.

Simplified formula for particle size determination by X-rays. R. BRILL. *Z. Krist.*, **95**, 455–56 (1936). H.I.

Splitting the minus 200 with the superpanner and infrasizer. H. E. T. HAULTAIN. *Can. Mining & Met. Bull.*, No. 301, pp. 229–40 (1937).—Two laboratory units have been devised for control of mill operation. The superpanner's essential features are a suitably supported specially shaped, 30- x 10-in. aluminum pan to which is cemented a special linoleum. The pan is bent with a gradually decreasing radius of curvature. The mechanism permits of eight adjustments which can be made easily while in operation, but only three adjustments are generally used, *viz.*, the slope of the pan, the speed of the end bump, and the speed of the gentle side motion. The end bump tends to move forward the mass of sands on the pan, while the wash water and the side motion tend to wash surface particles to the lower end. The heavier concentrates, finding their way to the surface of the pan, come to a fine tip and can be removed by a small suction pipet. Excess water and tailings are removed by continuous suction through a tube at the lower end of the pan, a bottle being interposed to collect tailings. The range of sizes that can be treated is from 65-mesh down to 14 microns. Two difficulties in the size analysis of very fine particles are the detaching of particles from each other and the maintaining of a uniform upward flow of air in the sorting column. These are overcome in the infrasizer by the use of a cone and ball device at the lower end of the sorting column, the essential feature being an ordinary golf ball resting in the cup of a rubber plug. The ball rotates and wabbles, giving a gentle rubbing action and effectively separating the particles; it also helps in the distribution of the upward flowing air current and acts as a valve to prevent back flow of air when the current is shut off. This apparatus yields quite accurate results in splitting minus 200-mesh materials, and the superpanner, when used in conjunction with it, will do very delicate work. Several units are in use in Canadian mills.

G.M.H.

Splitting small samples accurately. ANON. *Eng. Mining Jour.*, **138** [4] 185–86 (1937).—The microsplitter described was developed coöperatively at the University of Utah by the Bureau of Mines and the Utah Engineering Experiment Station. The device is essentially a miniature Jones riffle designed to deliver samples of size required for analyses. Two sizers are described in detail with the aid of dimensioned drawings. One cuts down samples to the proportions required for assaying and chemical analysis. The other delivers samples of size suitable for quantitative microscopic counts. The material preferred for construction is aluminum or brass. J.L.G.

Studies of diatomite insulating materials with a testing balance. E. RAISCH AND W. WEYH. *Wärme- & Kälte-Tech.*, **39**, 1–4 (1937); abstracted in *Chem. Zentr.*, **1937**, **i**, 2848.—Tests show that this special balance measures the water content correctly and can therefore be used for determining indirectly the coefficient of thermal conductivity and volume of the materials. M.V.C.

Unit control burner for oil-fired furnaces. NU-WAY HEATING PLANTS, LTD. *Metal Ind.* [London], **49** [20] 490–91 (1936).—The Rotavac oil burner makes use of the vacuum created at the vortex of rotating air to get the fuel velocity which can not otherwise be obtained except by gravity head or a mechanical pump. The velocity of oil drawn through under these conditions is exactly proportional to the velocity or quantity of air used, and the relation holds good for all air velocities. Rotavac atomization is a combination not only of the fuel velocity and the centrifugal force but also of the rarefied atmosphere caused by this partial vacuum. This combination, without any parts, gives a remarkable degree of atomization. The burner is illustrated. H.E.S.

Wet milling. K. WACHWITZ. *Keram. Rundschau*, **44** [42] 502–503 (1936).—The milling is due to the rolling of balls on each other; the drum wall and the fall of balls do not play a part in wet milling. W. divides the vertical diameter in 16 parts. The highest efficiency is reached when the ball level is 7 and the ceramic mix level is 12 to 13. F.E.V.

BOOKS

Boiler Fuels and Trials. A. S. CALLEN. International Textbook Co., Scranton, Pa., 1933. Price $1.00. Reviewed in *Mech. Eng.*, **57** [7] 456 (1935).—The composition and characteristics of coal and fuel oil, their analysis, and proper methods of burning them are discussed.

F.G.H.

Fans. T. BAUMEISTER. McGraw-Hill Book Co., New York, 1935. 241 pp. Price $3.50. Reviewed in *Mech. Eng.*, **57** [11] 736 (1935).—The primary object of this book is to assist the fan user in the selection of the best equipment for given service conditions. B. reviews the commercial types available, gives an analysis of uses, and discusses performance and the criteria and methods of selection. Chapters are devoted to design and testing and to the flow of fluids. Each chapter has a bibliography. F.G.H.

Investigations in Ore Dressing and Metallurgy, July to December, 1935. ANON. *Can. Dept. Mines & Resources, Mines & Geol. Branch, Bur. Mines Pub.*, No. 771, 234 pp. (1937).—Seventy-six investigations, mainly of metallic ores, are reported fully or in synoptic form. Of possible interest to ceramists are the following synoptic reports: (1) recovery of 95% of the available ilmenite as a high-grade concentrate can be obtained by wet-table methods from a massive ilmenite intergrown with 5% silicate minerals and hematite crushed to 7-mesh, from St. Urbain, Quebec: (2) recovery of about 90% of a concentrate running about 45% MgO can be obtained by flotation of a magnesite at Marysville, B.C.; (3) removal of iron from nepheline syenite from Peterborough County, Ont., should be accomplished by running 20- to 80-mesh material through a high power magnetic machine; (4) a sample of chromite running 39.42% Cr_2O_3 from Ashcroft, B.C., is suitable as received for refractories; (5) samples of gypsum from Windsor, N.S., and from Moose River, northern Ont., will make good plaster, and the latter is suitable for finishing and for the manufacture of all materials having a gypsum base. G.M.HUTT

PATENTS

Apparatus for spray drying. W. S. BOWEN. U. S. 2,081,909, June 1, 1937 (Nov. 20, 1934).

Automatic feeding and weighing machine. S. G. MURRAY. U. S. 2,083,391, June 8, 1937 (Jan. 14, 1936).

Filter. R. F. Norris (C. F. Burgess Laboratories, Inc.). Can. 363,217, Jan. 5, 1937 (Nov. 1, 1935). G.M.H.

Filter fabric and method of forming. R. P. Hayden (Johnson and Johnson, Ltd.). Can. 363,714, Jan. 26, 1937 (Nov. 18, 1935). G.M.H.

Filtering apparatus. H. A. Wienecke. Can. 363,644, Jan. 26, 1937 (March 16, 1935). G.M.H.

Granular material volume, weight, and density determining apparatus. Alfred Hanique. Can. 364,373, Feb. 23, 1937 (Dec. 21, 1935). G.M.H.

Magnetic separation. F. R. Johnson (Exolon Co.). Can. 363,504, Jan. 19, 1937 (May 21, 1934). G.M.H.

Method and means for feeding and forming plastic material in the manufacture of pottery. W. J. Miller. U. S. 20,401, June 8, 1937 (July 18, 1935); reissue of original 1,769,528 (*Ceram. Abs.*, **9** [9] 755 (1930)).

Mixing drum. E. H. Lichtenberg and F. H. Heine (Koehring Co.). Can. 363,885, Feb. 2, 1937 (Dec. 16, 1935). G.M.H.

Portable kiln. C. S. Bang. Can. 364,366, Feb. 23, 1937 (April 25, 1936). G.M.H.

Pottery manufacture. E. T. Smith. Brit. 465,539, May 26, 1937 (Jan. 30, 1936).

Pressure filter. A. O. Walker (Laurette A. Beeman). Can. 363,759, Jan. 26, 1937 (Jan. 31, 1936). G.M.H.

Sealing devices for rotary kilns, driers, etc. Vickers-Armstrongs, Ltd., and J. D. Sky. Brit. 465,382, May 20, 1937 (Feb. 26, 1936).

Spray gun. A. F. Jenkins. U. S. 2,082,060, June 1, 1937 (March 9, 1934). U. S. 2,082,061, June 1, 1937 (Jan. 12, 1935).

Stone crushing and breaking apparatus. W. A. Hiscox. Can. 364,086, Feb. 9, 1937 (Dec. 23, 1935). G.M.H.

Tube mill. Otto Liebeck. Can. 363,637, Jan. 26, 1937 (Dec. 26, 1934). A disintegrating mill comprises disintegrating elements of essentially stream-line shape and a means for introducing air into the mill under controlled pressure and in the direction of falling of the elements. G.M.H.

Kilns, Furnaces, Fuels, and Combustion

Briquetting coal with sodium silicate. Foster Dee Snell and Cyril S. Kimball. *Ind. Eng. Chem.*, **29** [6] 724–26 (1937).—A smokeless binder for briquets made by solution of silicic acid gel in sodium silicate appears to give properties quite different from those of a sodium silicate with the same ratio of sodium oxide to silicon dioxide. The briquets so made at a cost of $1.50/ton for binder are moderately resistant when exposed to water. They show an increase of ash content under 4% and no reduction in the fusion point of the ash. When made with anthracite culm, they burn completely, leaving an ash skeleton of the same shape as the briquet. Additional resistance to water can be obtained by pretreatment of the culm with a complex dispersion of aluminum palmitate or, to a lesser degree, by surface treatment of the briquets with a diluted form of the same dispersion. Such additional treatments increase the cost to a degree which is probably prohibitive commercially. F.G.H.

Burning of cracked-residue fuel oils. M. J. Haulon. *Mech. Eng.*, **57** [4] 241–43 (1935).—The heating values and characteristics of high-grade fuel oil, bunker "C" oil, and cracked-residue fuel oil are described. H. discusses the essentials for efficient combustion of these fuels. F.G.H.

Check flue-gas analysis without computation. John G. Fairfield. *Power*, **79** [1] 25, 36 (1935).—F. presents a graphic method for checking flue-gas analyses which have been made by means of an Orsat apparatus. F.G.H.

Colloidal fuel: II. J. L. Strevens. *Colliery Eng.*, **13** [6] 200 (1936).—Preparation and specifications of colloidal fuels are given. For Part III see *Ceram. Abs.*, **16** [1] 35 (1937). P.E.G.

Experiences with heating resistances of iron-chromium-aluminum alloys at high temperatures. R. Rumler. *Elektrowärme*, **7** [4] 69–74 (1937).—Experiments are reported with Cr-Al-Co-Fe alloys (Kanthal) and with Cr-Al-Fe alloys (Megapyr) which prove that both can be used even at the high temperatures required for glass and ceramic processes; the Fe-Cr-Al group is especially suitable in the range from 1250 to 1350°C with proper shape and arrangement of the conductors in the furnace and taking into account the high temperature coefficient which requires about 20% higher voltage for full utilization of the heating elements. The effect of shape, of arrangement of the heaters in the furnace, and of gases and other substances on the temperature and the life of the heaters is given in curves and photographs. M.H.

Phase equilibria in hydrocarbon systems: XVIII, Thermodynamic properties of ethane. B. H. Sage, D. C. Webster, and W. N. Lacey. *Ind. Eng. Chem.*, **29** [6] 658–66 (1937).—Specific volumes, Joule-Thomson coefficients, and isochoric specific heats have been determined for ethane. From these and other primary data, values of heat content and entropy have been calculated for a series of temperatures from 70 to 250°F and at pressures from atmospheric to 3500 lb./sq. in. abs. Several diagrams illustrate the thermodynamic behavior of this material. F.G.H.

Propagation of a zone of combustion in powdered coal. Effect of fineness of coal dust upon its rate of propagation. H. E. Newall. *Fuel*, **14** [6] 160–67 (1935).—Work on the propagation of a zone of combustion in powdered coal was undertaken in the belief that the measurement of the rate might provide a rapid and simple routine test for differentiating coals according to their tendencies to spontaneous heating. Illustrated. F.G.H.

Solid smokeless fuel. S. Clark Jacobson and George W. Carter. *Mech. Eng.*, **57** [5] 305–308 (1935).—The production of solid smokeless fuel by the low-temperature carbonization of Utah and Wyoming coals is discussed in detail. Illustrated. F.G.H.

Technical control of operation of furnaces. Victor Bodin and P. Gaillard. *Céramique*, **39** [581] 157–64 (1936).—Continuous furnaces are always more advantageous from any point of view; however, they can not be operated below a minimum. Intermittent furnaces are the only ones which can be adapted to the variation of the rate of production. However, their output is far below

that of continuous furnaces and their consumption of fuel is relatively high. The use of various types of fuel, mechanical stoking, control of operation, measurement of temperature, analysis of gas, etc., are dealt with.

M.V.C.

BOOKS

Carbonizing properties and petrographic composition of Millers Creek bed coal from Consolidation No. 155 mine, Johnson County, Ky., and effect of blending Millers Creek coal with Pocahontas bed and Pittsburgh bed (Warden mine) coals. A. C. FIELDNER, J. D. DAVIS, R. THIESSEN, W. A. SELVIG, D. A. REYNOLDS, G. C. SPRUNK, AND C. R. HOLMES. *U. S. Bur. Mines Tech. Paper*, No. 573. 50 pp. Price 10¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. R. A. HEINDL

Handbook of Butane-Propane Gases. Edited by G. H. FINLEY. Western Gas, Los Angeles, Calif. 2d ed. 375 pp. Price $5.00. Reviewed in *Mech. Eng.*, **57** [7] 457 (1935).—The handbook provides a comprehensive survey of the growing liquefied petroleum-gas industry, prepared by a number of specialists. The physical and chemical properties of these gases, methods of testing and analysis, their manufacture from natural gas and extraction from refinery gases, transportation, storage, distribution, and uses are all discussed. A large amount of practical information is brought together in convenient form. There is an extensive bibliography, covering the literature from 1926 to 1934. F.G.H.

List of Books and Other Sources of Information Regarding Coal and Coal Products. Compiled by F. R. WADLEIGH. Washington, D. C., 1935. 63 pp. Price $1.00. Reviewed in *Mech. Eng.*, **57** [9] 602 (1935).—Books on coal and the coal industry are listed, accompanied by lists of societies, coal commissions, periodicals, government departments, and other sources of papers and pamphlets upon these subjects. The bibliography is confined to the English language. The entries, which are classified for convenience, cover the geology, mining, economics, and utilization of coal and its products.

F.G.H.

PATENTS

Ceramic furnace. E. J. DUSSERIS. U. S. 2,081,476, May 25, 1937 (Oct. 16, 1935). A continuously operable furnace of the Hoffman type is described.

Tunnel kiln. TECHNOTHERMIE SOC. Brit. 465,085, May 13, 1937 (July 1, 1935).

Tunnel kiln and method of operating. G. D. PHILLIPS. U. S. 2,081,954, June 1, 1937 (Aug. 10, 1934; renewed Aug. 10, 1936). In the operation of a continuous tunnel kiln, the method of regulating gas flow and temperatures in the preheating zone of the kiln consists in withdrawing kiln gases at the low-temperature end of the zone, as required to maintain a suitably large volume of gas flow through a section of the zone adjacent the end, and in injecting hot gases into the lower portion of the section.

Geology

Buchanan's laterite of Malabar and Kanara. C. S. FOX. *Records Geol. Survey India*, **69** [4] 389–422 (1935).—The original type area of laterite in south India was reexamined. Buchanan's original laterite consists mainly of lithomargic laterite and partly of laterite lithomarge. The term "lateritization" means an end process of weathering beyond that of kaolinization, whereby the hydrated silicates break down into the hydroxides of alumina and iron, which remain, and silica, which is removed in solution. Every stage in this process can be found, from the formation of kaolin or lithomarge to the final condition practically devoid of silica and with aluminium hydroxide and ferric hydrate as the two essential components. When the ferruginous component is in excess, the term "ferruginous laterite" may be employed; when the aluminous component is in excess and above 50%, it may be called "aluminous laterite" or "bauxite." Buchanan's laterite belongs to neither of these, yet its vermicular texture is that of laterite and indicates that although kaolinization has been active, the final stage, lateritization, has been entered. The term "laterite" remains, however, a convenient field term for uncertain material with the characteristic vermicular texture. A.P.S.

Calcium borate as pandermite in ceramics. RAOUL DE BLOTTEFIÈRE. *Céram., Verrerie, Email.*, **4** [9] 351–56 (1936).—Borax minerals and boron minerals containing boric acid which are used in the ceramic industry are discussed in detail. To these groups belong raw boric acid of Tuscany, impure Na-borate known as tincal (China, Tibet, India), borazite of the formula $2(3MgO{\cdot}4B_2O_3) + MgCl_2$ (Bolivia), and Norwegian datolite ($2CaO{\cdot}B_2O_3{\cdot}2SiO_2{\cdot}H_2O$). The European ceramic industry employs chiefly borocalcite, which is known as pandermite, from Anatolia (on the shores of the Sea of Marmora). Pandermite contains 55% B_2O_3 and 37% CaO. An advantage of this mineral, which melts at 1160°C, is that it has a high B_2O_3 content and that it yields its constant water without swelling. Examples of its use in industry are given. M.V.C.

Ceramic interests in the Division of Geology and Geography of the National Research Council. ROBERT B. SOSMAN. *Bull. Amer. Ceram. Soc.*, **16** [6] 249–50 (1937).

Ceramic materials of Bresse. V. CHARRIN. *Céram., Verrerie, Email.*, **5** [3] 95–97 (1937).—The geological formation of two representative deposits of refractory and pottery clay in the Bresse region is explained. M.V.C.

Changes in chemical composition of igneous rocks by weathering: I, Granites. GOTTFRIED GROSSER. *Chem. Erde*, **11**, 73–216 (1937).—Detailed studies of the changes in chemical composition from fresh to weathered rock of the same source are given. H.I.

Chemical composition of pollucite. HUGO STRUNZ. *Z. Krist.*, **95**, 1–8 (1936).—Pollucite is a zeolite-like mineral with the composition $[Si_4Al_2O_{12}]Ca_2{\cdot}1H_2O$. The lattice constant is $a_0 = 13.71$ Å, and the probable space group $O_h^{10}-Ia\,3d$ with 8 molecules to the unit cell. Pollucite is closely related crystallographically and chemically to leucite and analcite. H.I.

Chemical determination of ore minerals by the "pressure method" (use of contact analysis on thin sections).

R. GALOPIN. *Schweiz. mineralog. petrog. Mitt.*, **16**, 1–18 (1936); abstracted in *Chem. Zentr.*, **1937**, **i**, 2345.—The thin sections are treated with reagents, mostly acids, and covered with filter paper on whose surface the reagent necessary to detect the element is deposited. Either a deposit or a characteristic coloring is formed. The decomposition can be performed also by electrolysis in the presence of acid. Instead of filter paper, a film free from Ag salts and saturated with the acids used is also employed. M.V.C.

Chemicopetrographical investigation of clays. T. A. GURVICH, L. I. KARYAKIN, AND V. B. KRAFT. *Zavodskaya Lab.*, **5** [12] 1474–79 (1936).—A comparative investigation of the mineralogical composition of clays by the petrographic and rational methods of analysis showed that the results do not always correspond in both cases. The results of rational analysis by the Harkort method for kaolins and refractory clays are more reliable than those obtained petrographically. This method can not be applied to clays in which the kaolinite group minerals do not form the fundamental mass; in this case the petrographic analysis is more expedient. Both methods should be used in most cases when studying the mineralogical composition of clays. P.B. & E.S.

Constitution of the earth. J. H. REYNOLDS. *Nature*, **139** [3512] 314–16 (1937).—R. considers some of the theories proposed for the constitution of the earth's interior and the assumptions made in the extrapolations used. J.L.G.

Crystal structure of kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, and the composition of anauxite. STERLING B. HENDRICKS. *Z. Krist.*, **95**, 247–52 (1936).—Electron and X-ray diffraction data were obtained from oriented aggregates of kaolinite and anauxite. These data are in agreement with the predictions based on the structure of kaolinite as determined by Gruner (*Ceram. Abs.*, **12** [10–11] 395 (1933)). Increase in the SiO_2/R_2O_3 ratio in anauxite above that required for $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ is brought about by subtraction of aluminum ions and hydroxyl groups rather than by isomorphous replacement of Al by Si in the $Al_2Si_2O_5(OH)_4$ layers. H.I.

Crystallization process of basalt (a supplement and a reply). TOM F. W. BARTH. *Amer. Jour. Sci.*, [5] **31**, 321–51 (1936).—As a first approximation, a basalt can be regarded as a rock composed of two mineral phases: (1) plagioclase feldspars which form a reaction series from calcic to sodic, with or without individual crystals of alkali feldspar as the last product; (2) pigeonite pyroxenes which form a reaction series from diopsidic to clinohypersthenic. Depending upon the initial composition of the basaltic magma, either plagioclase or pyroxene will start to crystallize, changing the composition to a point where simultaneous crystallization occurs. The conditions for such simultaneous crystallization are reduced to an equation in terms of the normative components. B.'s conclusions are in accord with those of Tsuboi (*Ceram. Abs.*, **12** [4] 170 (1933)). Kennedy (*Amer. Jour. Sci.*, **25**, 239 (1933)) is professedly in opposition to B.'s views yet their main conclusions are identical. Powers (*ibid.*, **30**, 57 (1935)) disagrees with B. on both facts and conclusions. See *Ceram. Abs.*, **10** [8] 596 (1931). J.B.A.

Density and structure of zircon. K. CHUDOBA AND M. v. STACKELBERG. *Z. Krist.*, **95**, 230–46 (1936).—Three zircon types, *a*, *b*, and *c*, are postulated. The *a* type (of lowest density) is considered to contain larger quantities of a lighter, amorphous zirconium silicate. By heating to 1450 °C the *a* and *c* zircons are transformed to the densest *b* type. H.I.

Determination of kaolin and clay in siallites. A. VASEL. *Keram. Rundschau*, **44** [47] 559–60 (1936).—Although chemical analysis shows slight discrepancies, there is as much difference in the siallites as in the original feldspathic rocks. Potash feldspar gives kaolin and soda feldspar gives clay. Humic materials increase plasticity and are considered as argillaceous substances. The results of chemical and rational analyses (of dry clay) and the resistivity against NaOH (of fired clay) being known, V. computes by a formula the mineral composition (kaolin, clay, quartz, feldspar, and organic matter). F.E.V.

Diatomite, its deposits, properties, and uses. V. CHARRIN. *Chimie & Industrie*, **37** [4] 810–17 (1937).—The name diatomite is reserved for sedimentary accumulations made up for the most part of the remains of algae of fresh and salt water, wherein organic silica is the main component, whose characteristics are lightness, porosity, and great insulating power. The deposits, preparation, properties, and uses of diatomite are given at length. M.V.C.

Diatomites of Cantal. V. C. *Rev. Matériaux Construction Trav. Publics*, No. 330, pp. 46–47B (1937).—The composition of these diatomites varies from 72.40 to 91.50% SiO_2, 1.50 to 5.10% Al_2O_3, 1.80 to 18.20% organic matter, and 2.30 to 3.01% H_2O with small amounts of TiO_2, Fe_2O_3, CaO, and MgO. The heat-insulating brick made from the best of these earths ranks with those of other origin. M.V.C.

Economic minerals of Gangpur State, Bihar, and Orissa. M. S. KRISHNAN. *Trans. Mining & Geol. Inst. India*, **30** [2] 73–92 (1936).—The occurrences of economic importance are barytes, building stones (granite gneiss, marble, slate, quartzite and quartz schist, sandstone, road metal, clays, coal, feldspar, limestone, and dolomite), manganese ore, red ocher, and fire clay. A.P.S.

"Ferrosilite" as a natural mineral. N. L. BOWEN. *Amer. Jour. Sci.*, [5] **30**, 481–98 (1935).—The crystallographic and optical properties of minute needles found in the lithophysae of an obsidian from Lake Naivasha, Kenya Colony, correspond with those of pure $FeSiO_3$ as determined by extrapolation in a series of monoclinic pyroxenes. Previous studies on synthetic minerals have indicated that $FeSiO_3$ can not occur as a crystalline compound. Reëxamination of the laboratory data shows that the possibility of the formation of substantially pure $FeSiO_3$ at a temperature of 600 °C or less is not precluded. The needles are therefore accepted as $FeSiO_3$. Washington's normative term "ferrosilite" is extended to the natural mineral, and the name "clinoferrosilite" is given to the crystals. J.B.A.

Fibrous brucite. J. GARRIDO. *Z. Krist.*, **95**, 189–94 (1936).—The orientation of crystal planes with respect to fiber direction is determined by X-ray patterns. After loss of H_2O on heating at 500 °C, the MgO crystals formed are oriented with respect to the original brucite fiber. H.I.

Geology of the northern slopes of the Satpuras between the Morand and the Sher rivers. H. CROOKSHANK. *Mem. Geol. Survey India*, **66** [2] 173–381 (1935).—Specimens of chrysotile asbestos were found but so far no workable deposits. Clays, probably suitable for fire brick, occur in the Gondwanas, and an excellent tile clay is found as a decomposition product, *in situ*, of the crystalline limestone. Quartzites suitable for silica brick occur but are not at present used. Coal occurs in at least three horizons of the Gondwanas of which the Barakar is of economic importance. 11 plates. A.P.S.

Hydrated aluminous silicates. VICTOR CHARRIN. *Céram., Verrerie, Email.*, **4** [12] 475–76 (1936).—Deposits, composition, properties, and applications of aluminous hydrosilicates are described, with special regard to pholerite (kaolinite), $2Al_2O_3 \cdot 3SiO_2 \cdot 4H_2O$; allophane, $Al_2O_3 \cdot SiO_2 \cdot 6H_2O$; pyrophyllite, $Al_2O_3 \cdot SiO_2 \cdot H_2O$; halloysite, $Al_2O_3 \cdot SiO_2 \cdot 2$ to $4H_2O$; and montmorillonite and bentonite. M.V.C.

Influence of different liquids on the refractive index of clay minerals. F. A. VAN BAREN. *Z. Krist.*, **95**, 464–69 (1936).—In the microscopic determination of the refractive indices of clay minerals by the immersion method, the refractive indices are found to be dependent on the water content of the mineral and the immersion liquid used. The use of liquids containing constitutional (NH_2) groups should be avoided, since these appear to raise the index of the immersed clay minerals considerably. H.I.

Kaolin and clay; difference in their geologic origin. A. VASEL. *Keram. Rundschau*, **43** [44] 517–19 (1935).—The chemical decomposition of feldspathic and micaceous rocks may be realized (1) by acidic volcanic gases and (2) by atmospheric action. The second process, in arid climates, gives laterite nearly free from silica and alkalis; in moist climates, siallites (kaolin and clay) are produced. G. Daubrée verified, by laboratory tests, that ground orthoclase is slightly soluble in water at room temperature. The presence of humic acid has no influence on the atmospheric decomposition. The nature of the rock determines the formation of kaolin or clay. The purity of siallites depends on the iron and titanum content of the original rock. The humic acid does not de-iron the raw materials, but the infiltration of organic matters causes the formation of iron sulfides. F.E.V.

Lepidolite. A. M. HERON. *Records Geol. Survey India*, **71** [1] 45 (1936).—A lepidolite pegmatite found in Bastar State is 30 ft. wide and 70 yd. long, the lepidolite being confined to the center of the vein. About 15 tons of lepidolite would be obtained for every foot in depth, necessitating also the mining of 90 tons of quartz. A.P.S.

Lightweight product possibilities of the Porters Creek clay of west Tennessee. GEORGE I. WHITLATCH. *Tenn. Div. Geol. Resources Tenn.* (2nd Ser.), No. 1 (1937).—The Porters Creek clay, a very abundant and accessible but undeveloped natural resource of Tenn., fires naturally to exceptionally low densities. Data on 19 localities show that, between cones 1 and 12, the apparent specific gravity ranges from 1.29 to 1.58, and the apparent porosity, to which the levity is due, averages 40%. The possibilities of adapting such natural lightweight firing clay to lightweight structural, acoustical, and refractory units are considered on the basis of present laboratory and plant tests. Good quality common brick with 25% less weight than ordinary clay brick and crushing strength in excess of 2000 lb./sq. in. have been made in plant tests. Test pieces of the clays, fired to cone 1, have successfully withstood 18 cycles of freezing and thawing. Additions to the clay of 10 and 25% of lignitic clay from nearby west Tenn. mines, with firings to cone 1, gave products of 1.09 and 0.91 apparent specific gravity, respectively, or, by calculation, 60 and 57 lb./cu. ft. The chief economic uses of the Porters Creek clay will probably be in making structural insulating units where the natural lightweight property will permit low-cost production. Refractoriness of the clay is too low for high-temperature insulation, but commercial tests indicate possible adaptation to back-up insulators. The high porosity of the fired clay is suggested as favorable for acoustical units. The report is introduced by a summary of the current status of the lightweight products industry in the U. S., indicating the rapidly expanding commercial application of such products in the refractories field and the new trends in construction, such as air-conditioning, that favor lightweight porous products. G.I.W.

Micrometric estimation of quartz in rocks. S. H. SHAW. *Bull. Inst. Mining & Met.*, No. 385, 19 pp.; No. 386, pp. 9–22 (1936); No. 391, pp. 27–28 (1937).—Micrometric and rational analyses of igneous rocks agree closely. The former gives low results on sandstones owing to the very fine quartz. It is unsuitable for shales. A.H.E.

Microphotometric study of X-ray powder diagrams of certain feldspars. T. ITO AND H. INUZUKA. *Z. Krist.*, **95**, 404–407 (1936).—Photometric records of powder patterns of perthite and microperthite show "doublet" peaks very similar to those obtained from mechanical mixtures of albite and orthoclase, indicating that microperthites are actually fine intergrowths of different feldspars and not a single-phase feldspar, repeatedly twinned. H.I.

Montmorillonite from Dolmar at Meiningen. HERMANN JUNG. *Chem. Erde*, **11**, 217–22 (1937).—The chemical composition, X-ray powder pattern, and optical and other properties of montmorillonite from this locality are given. The H_2O and MgO contents are relatively high, the Al_2O_3 relatively low. H.I.

Potash-soda feldspars: I, Thermal stability. E. SPENCER. *Mineralog. Mag.*, **24** [156] 453–95 (1937).—A series of potash-soda feldspars of the orthoclase-microperthite type, selected with increasing soda contents up to 60%, were examined and found to exhibit a progressive relationship between chemical composition and physical properties. Albite conforms in physical properties to the soda end-member of the series. Adularia and microcline are not included in the series because of high birefringence and 2V, and sanidine and anorthoclase because of low birefringence and low 2V. Sanidine and anorthoclase show complete solid solution of the Na_2O component, probably due to rapid cooling through the temperature range 1050 to 900°C. Microperthite of the orthoclase-microperthite series is of the ex-solution type and can be taken into solid solution again by heating to 750 to 800°C followed by rapid cooling. The optic axial angles of potash-soda feldspars are reduced by prolonged heating at high temperatures. Tables are given showing chemi-

cal composition and optical and other properties of the potash-soda feldspars examined. H.I.

Raw material requirements in the whiteware and glass industries. E. H. FRITZ. *Bull. Amer. Ceram. Soc.*, **16** [6] 231–33 (1937).

System Cu–Fe–S. H. E. MERWIN AND R. H. LOMBARD. *Econ. Geol.*, **32** [2] 203–84 (1937).—M. and L. investigated the 4 binary and the 5 ternary crystalline compounds and eutectic mixtures and solid solutions of the Cu–Fe–S system. The seven compounds existing as natural minerals are pyrite, pyrrhotite, cubanite, chalcopyrite, bornite, covellite, and chalcocite. The two compounds which do not have mineral names have the formulas Cu_2FeS_3 and $Cu_3Fe_4S_6$. Results are explained with the aid of ternary diagrams, vapor-pressure curves, and tables. J.L.G.

Talc and soapstone. ANON. *Mineral Ind.*, **44**, 562–65 (1935).—Domestic consumption of talc is chiefly for paints, paper fillers, roofing, rubber, and ceramics. N. Y. produces the most, followed by Vt., Calif., and N. C. Production in 1935 was 172,000 tons, an increase of 12%. The price per ton varied from $4.00 to $15.00. Imports increased 17% to 23,800 tons. Exports were 5800 tons. See *Ceram. Abs.*, **16** [1] 42 (1937). G.M.P.

Tektite problem. L. J. SPENCER. *Mineralog. Mag.*, **24** [156] 503–506 (1937).—The meteoric theory and the meteorite-crater theory of the origin of the type of natural siliceous glasses known as tektites are compared. H.I.

Vanadium-bearing muscovite from Schmiedefeld. HERMANN JUNG. *Chem. Erde*, **11**, 38–44 (1937).—The X-ray powder pattern, chemical composition, and dehydration curve of a green mineral heretofore called pyrophyllite from the iron deposits of Schmiedefeld in Thüringia were determined. The properties correspond well with those of muscovite containing about 1% V_2O_3. H.I.

Water content of the minerals kaolinite, halloysite, and montmorillonite. M. MEHMEL. *Chem. Erde*, **11**, 1–15 (1937).—Weight-loss and refractive-index measurements made upon halloysite, kaolinite, and montmorillonite gave the following results: (1) Halloysite at 0 mm. water-vapor pressure loses 2 mol. H_2O with the consequent formation of a new crystal lattice (metahalloysite) having the same chemical formula as kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) and losing the remainder of its H_2O at the same temperature as does kaolinite. (2) The H_2O content of most natural halloysites is less than 4 mol. because of a partial transformation to metahalloysite. (3) Kaolinite loses its H_2O suddenly between 400 and 450°C with a corresponding sudden change in refractive index. (4) Montmorillonite loses the principal part of its H_2O continuously at 200°C with a simultaneous lattice shrinkage in the direction of the *c*-axis. (5) Montmorillonite loses little H_2O between 200 and 400°C and in this interval has a characteristic, brucite-like lamellar structure. (6) Montmorillonite loses the rest of its H_2O between 400 and 450°C. See "Optical—," *Ceram. Abs.*, **16** [1] 39 (1936). H.I.

BOOKS AND BULLETINS

Analyses of rocks and minerals from the laboratory of the United States Geological Survey, 1914–36. Tabulated by R. C. WELLS. *U. S. Geol. Survey Bull.*, No. 878. 134 pp. Price 15¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. This supplements *Bull.* No. 591 and covers material beginning with 1915. W. tabulates rock analyses by locality and the minerals by name. Record numbers are given so that even the projects involved can be located. R.A.HEINDL

Canadian Mines Handbook, 1937. ANON. Northern Miner Press, Toronto, Ont. 383 pp. Price $1.00. Reviewed in *Eng. Mining Jour.*, **138** [4] 218 (1937).—4714 Canadian mining companies are listed. J.L.G.

Engineering Geology. H. RIES AND T. L. WATSON. John Wiley & Sons, New York, 1936. 5th ed. 750 pp., 271 figs. Price $5.00. Briefly reviewed in *Econ. Geol.*, **32** [2] 188 (1937).—This edition includes minerals, rocks, and structural, general, economic, and historical geology. J.L.G.

Interpretative Petrology of the Igneous Rocks. H. L. ALLING. McGraw-Hill Book Co., Inc., New York, 1936. 353 pp., 11 plates, 48 figs. Price $4.00. Reviewed in *Econ. Geol.*, **32** [2] 185–86 (1937).—A. presents phase-rule chemistry as applied to igneous rocks. J.L.G.

Mining Yearbook, 1937. ANON. Published by Walter E. Skinner, London. 1040 pp. Price 21s 6d, post free abroad. Reviewed in *Eng. Mining Jour.*, **138** [4] 218 (1937).—This volume lists and describes the operations of 1323 of the world's principal mining companies. Numerous maps of mining properties are included. J.L.G.

Sulfuric acid leaching of Washington clays for the production of alumina and aluminum metal. H. C. PARKMAN. *State Coll. Wash. Met. Research Lab., Bull. E*, 51 pp. (1935).—P. reviews methods and gives flow sheets for known processes of leaching. Experimental work using clay from Freeman, Wash., is described. Counter-current leaching with 50% sulfuric acid at elevated temperatures below the boiling point is suggested. Crystallization of aluminum sulfate or potash alum is possible. P. points out, however, that these are laboratory tests and a larger scale investigation would be needed to determine feasibility. A.G.STERN

Survey of the aluminum industry and its metallurgical processes. R. M. MILLER. *State Coll. Wash., Met. Research Lab., Bull. D*, 71 pp. (1935).—Special reference is made to the utilization of Northwestern clays. M. points out that one-half of domestic aluminum requirements are met by Arkansas bauxite; the remainder is imported from Guiana. Possible domestic sources other than bauxite are alunite and leucite which contain 10 to 11% Al_2O_3 and the same amount of potash. Northwestern clay is also a possible source. Although metallurgically simple, at present it probably would be costly to operate. Using clay as a source of alumina would probably not be competitive with bauxite. The literature is reviewed and flow sheets of various methods proposed are presented. A.G.STERN

PATENTS

Decomposition of beryllium minerals. GUSTAV JAEGER (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). Can. 364,158, Feb. 16, 1937 (May 2, 1935). G.M.H.

Process of concentrating beryllium oxide occurring in minerals containing beryllium silicate. LOUIS BURGESS. Can. 363,631, Jan. 26, 1937 (April 23, 1935). G.M.H.

Chemistry and Physics

Analysis of feldspar—determination of ferric oxide: I, Decomposition of sample. E. W. KOENIG. *Jour. Amer. Ceram. Soc.*, **20** [7] 230–33 (1937). **II, Application of titanometry.** *Ibid.*, pp. 233–35.

Calcined mixtures of litharge and titanium dioxide. X-ray diffraction study. DOUGLAS G. NICHOLSON. *Ind. Eng. Chem.*, **29** [6] 716–17 (1937).—An X-ray diffraction study of calcined samples of mixtures of litharge and titanium dioxide shows conclusively that a definite chemical compound is formed when the molecular proportion of the two substances is in the ratio of 1:1. Any deviation from the 1:1 ratio results in a physical mixture of this compound with the constituent present in excess. The X-ray diffraction patterns produced by calcined 1:1 mixtures of (1) litharge and commercial titanium dioxide, (2) lead nitrate and hydrous titanium oxide, and (3) lead hydroxide and hydrous titanium oxide are identical with that produced by a sample of commercial lead titanate. Illustrated. F.G.H.

Changes of the melting point and the "degeneration" of cryolite by fusion in air. V. P. MASHOVETZ. *Zhur. Prik. Khim.*, **9**, 789–800 (in German 801) (1936).—If held for a considerable time in contact with air, the temperature of solidification and the character of the solidification curve of cryolite change. The "degeneration" of cryolite takes place by interaction with oxygen or with air moisture under formation of aluminium oxide and loss of fluorine. The mechanism of the "degeneration" process has been confirmed by the coincidence of the temperatures of the beginning of crystallization of samples of "degenerated" cryolite and of synthetic mixtures corresponding to the same degree of "degeneration." Precise physicochemical investigations of cryolite fusions must be conducted without admission of air or in an atmosphere of dry inert gas in order to obviate its "degeneration." P.B. & E.S.

Character of outflow and structural properties of sodium silicate solutions. I. N. ZAVYALOV. *Zhur. Fiz. Khim.*, **8** [3] 411–19 (1936).—Z. concludes that sodium silicate solutions behave as ordinary viscous liquids following the Poiseuille formula and do not possess any specific structural viscosity. Though of a colloidal nature, sodium silicate solutions have a rather high stability to the influence of high temperatures (up to 90°C). P.B. & E.S.

Chemistry of zirconium dioxide. X-ray diffraction studies. G. L. CLARK AND D. H. REYNOLDS. *Ind. Eng. Chem.*, **29** [6] 711–15 (1937).—When $ZrOCl_2 \cdot H_2O$ is heated at 110°C, it loses its water of hydration and becomes amorphous. Between 300 and 500°C, it is transformed to zirconia. The tetragonal modification of zirconia is formed at 500°C and is converted to monoclinic baddeleyite above 600°C. When zirconyl hydroxide is ignited at 650°C, it first forms tetragonal zirconia which is then converted irreversibly to the monoclinic form. Complete conversion requires considerable time at that temperature. When zirconyl hydroxide is ignited at 500°C, tetragonal zirconia is formed which shows no tendency to change to monoclinic even upon long heating at this temperature. The low-temperature tetragonal form of zirconia is probably identical in structure with the form which is stable between 1000 and 1900°C. The slow conversion rate of the low form may be due to its extremely small crystal size. Silica exhibits some solubility in tetragonal zirconia. The dissolved silica stabilizes the tetragonal form to raise the transition temperature from 600 to above 1000°C. The silica-zirconia solution is converted to zirconium silicate (zircon) at 1460°C. Illustrated. F.G.H.

Coloroscopic investigations. T. A. THOMSON. *Mikrochemie*, **21** [2] 209–14 (1937) (in English).—Emich's "coloroscopic" method in conjunction with that described by Feigl has been tried on copper (with α-benzoinoxime), chromium as chromate (with diphenylcarbazide), chromium (with benzidine), cobalt (with rubeanic acid), mercury (with diphenylcarbazone), and manganese (with benzidine). The tests were found rapid and infallible. The method is not considered superior to Tüpfelanalyse, but it may have practical uses in microgeology. L.E.T.

Crystallization of silica in $NaPO_3$. GIORGIO PEYRONEL. *Z. Krist.*, **95**, 274–81 (1936).—The so-called SiO_2 skeletons in salt of phosphorus beads are found, by chemical, microscopic, and X-ray analysis, to be composed of pure cristobalite, β-cristobalite at the formation temperature, and α-cristobalite after cooling. P. discusses conditions of formation of cristobalite and of the compound $SiO_2 \cdot P_2O_5$. H.I.

Formula of β-alumina, $Na_2O \cdot 11Al_2O_3$. C. A. BEEVERS AND S. BROHULT. *Z. Krist.*, **95**, 472–75 (1936).—A correlation of structure data with the revised value for density, 3.24, suggests that the correct formula for β-alumina is $Na_2Al_{22}O_{34}$ rather than $NaAl_{22}O_{34}$ as suggested by Bragg, Gottfried, and West (*Ceram. Abs.*, **10** [8] 601 (1931)). X-ray analyses and density determinations on a new potassium β-alumina prepared by Norton Co. also indicate that the correct formula is $K_2Al_{22}O_{34}$. H.I.

Influence of adsorbed bases on the structural formation of clay suspensions (preliminary report). G. B. LARIN. *Zhur. Fiz. Khim.*, **8** [5] 790 (1936).—The increase of the content of adsorbed sodium calls forth an increase of hydration as a structure-forming factor; a second similar factor is coagulation. The adsorbed Na acting as a peptizing agent, the structure formation passes through a maximum where it increases. P.B. & E.S.

Molecular structure: II. H. J. EMELÉUS AND STEPHEN MIALL. *Chem. & Ind.*, **55** [42] 793–98 (1936).—The distinction between the three lattice types is not hard and fast. There are border-line cases. Nonionic lattices are the most common among organic substances, some of which are described. Molecular structures of some complex natural materials are discussed. X-ray investigation of the structure of the silicates depends primarily on the analysis of diffraction photographs obtained from natural crystalline materials. The crystal analysis shows that the silicon atom is always situated between four oxygen atoms. In the simplest silicates, orthosilicates, these separate tetrahedral SiO_4 groups act as tetravalent acid radicals and build up an ionic lattice with the positively charged metal ions. Zircon and garnet are minerals containing the simple SiO_4 group as a structural unit. A slightly more complex group is ob-

tained when two SiO_4 tetrahedra have one oxygen atom. This structural unit is really a pyrosilicate ion. The next type of structure found in silicates consists of chains of SiO_4 molecules formed by sharing of 2 out of the 4 oxygen atoms of each tetrahedral group. This grouping occurs in asbestos. A ring structure can also be extended in two dimensions and is found to be the structure of the micas and talcs. The crystals which contain these chains or sheets of silicate ions are still ionic. The oxygen atoms which are joined to only one silicon atom act as centers of attraction for the metal atoms which lie between the chains or sheets and cement them together. This type of binding will also explain the variable nature of the metallic constituents in silicates. When each SiO_4 tetrahedron shares every corner, a 3-dimensional network results. Other structures have been found in which silicon is partly replaced by aluminum in such a way that the ratio is 1:2. Owing to the lower valency of aluminum, the net-like structure now has a negative charge, and an equivalent number of positive metallic ions can be incorporated in the molecule to render the whole neutral. Feldspars are of this type; zeolites have a similar structure but are characterized by more open structure in which water molecules can be held. G.R.S.

Rapid analysis of Portland cement. TADAHIDE MIZUNO. *Jour. Soc. Chem. Ind. Japan*, **40** [2] 55–56B (1937).—When silica in Portland cements is determined by means of NH_4Cl, a single evaporation to dryness is sufficient, and the results are the same as those obtained by two evaporations without the addition of NH_4Cl. M.V.C.

Research on the decay of ceramic slips. PIERRE BREMOND. *Céramique*, **39** [583] 195–201 (1936).—Ceramic mixes contain numerous and varied microörganisms whose origin comes from air, water, or human treatment. The majority of them belong to saprophytes. Their development is promoted by the age of the mix. Alkaline surroundings, water, and air promote their formation and growth. M.V.C.

Restoration of plasticity in fired clays. C. GORIA AND G. VENTURELLO. *Chimica & Industria*, **18** [9] 453–56 (1936).—The conditions of plasticity of clays are reviewed. Three types of clays were investigated at different temperatures to determine on what factors the plastic state in fired clays depends. The three following factors are important: fineness of particles, laminar structure, and external gelatinous phase; the two last factors are of major importance. The chemical composition does not seem to have much effect but this point is not yet clear. M.H.

Solubility of hydrated alumina in solutions of caustic soda (system $Al(OH)_3$–$NaOH$–H_2O). S. M. TSYRLINA. *Legkie Metally*, **5** [7] 28–37 (1936); abstracted in *Chimie & Industrie*, **37** [4] 708 (1937).—Supersaturated solutions of aluminates are liable to decompose rapidly until their degree of supersaturation reaches 1.5 to 2. Whatever the temperature, the solubility curves are formed of two branches intersecting at the maximum. The augmentation of the concentration of Na_2O contributes to the increase of the solubility of $Al(OH)_3$. The elevation of the temperature also increases the solubility; between 30 and 60°C this effect is less noticeable than between 60 and 95°. M.V.C.

Solutions under high pressure. R. E. GIBSON. *Sci. Monthly*, **43**, 173–76 (1936).—Although it is possible to determine directly how much of a given solid water or any other liquid dissolves under very high pressures, it is not always convenient or necessary to do so. The well-established science of thermodynamics shows that, in order to determine changes in solubility with pressure, the only measurement which must be made under pressure is that of the volume changes. The small shrinkage of 1 cc. of water under a very high pressure is called the compression. This compression is known to become less as salt is dissolved in water. In general it is possible to calculate the compressions of solutions of solids in water up to the highest pressures under which the solutions will exist simply from observations at low pressures. Results on various solutions have been of value in revealing the nature of liquids and of the forces of attraction and repulsion which exist between the molecules of solids and liquids. The results have had a more recent adaptation to the study of rock formation and the composition and character of the earth's crust. H.E.S.

Spectroscopic analysis. N. S. BAYLISS. *Jour. Soc. Chem. Ind. Victoria*, **36**, 1182–94 (1936).—The technique of the spectroscope can not be quickly learned. The optics of the instrument, the characteristics of photographic plates and developers, and the excitation of spectra require a knowledge of theory and practice. Almost unexplored is the spectroscopy of the infra-red. H.H.S.

Structure of crystals. ULRICH DEHLINGER. *Physik*, **5** [1] 9–14 (1937).—A number of papers dealing with the structure of minerals, which have been published between January, 1933, and July, 1936, are discussed. The following chapters are included: (1) Methods of investigation (X-ray, electron microscope, etc.), (2) Survey of structure determinations, (3) Laws of crystal formations, (4) Deviations from periodical lattice structure, and (5) Kinetics of crystal growth, transformations, separations, and recrystallization. L.E.T.

Structure of pentacalcium trialuminate. W. BÜSSEM AND A. EITEL. *Z. Krist.*, **95**, 75–88 (1936).—On the basis of structure as derived from X-ray investigation, the so-called $5CaO{\cdot}3Al_2O_3$ is found actually to be $12\ CaO{\cdot}7Al_2O_3$. The calculated density is 2.69 g./cm.³, the cube edge is 11.95, and the probable space group is T_9^6. The optical homogeneity of completely crystallized 12:7 mixtures and the presence of small amounts of $CaO{\cdot}Al_2O_3$ in crystallized mixtures with the ratio $5CaO{\cdot}3Al_2O_3$ confirm the composition as determined from structure investigation. H.I.

System PbO–B_2O_3. R. F. GELLER AND E. N. BUNTING. *Jour. Research Nat. Bur. Standards*, **18** [5] 585–93 (1937).—The system PbO–B_2O_3 was found to contain four compounds (the optical properties of which are given), *viz.*, $4PbO{\cdot}B_2O_3$ occurring in two forms and melting congruently at 565°C, $2PbO{\cdot}B_2O_3$ occurring in two forms and melting incongruently at 497°C, $5PbO{\cdot}4B_2O_3$ melting incongruently at 548°C, and $PbO{\cdot}2B_2O_3$ melting congruently at 768°C. The identity of an additional crystal phase was not established. The lowest melting eutectic has the composition 88% PbO and 12% B_2O_3 by weight and melts at 493°C. Some properties of several of the compositions as glasses are given. R.A.H.

BOOKS

British Drug Houses Book of Reagents for Spot Tests and Delicate Analysis. ANON. British Drug Houses, Ltd., London, 1936. 5th ed. viii + 96 pp. Price 2s 6d. Briefly reviewed in *Nature*, **139** [3509] 176 (1937).—Spot tests can be carried out quickly in large numbers and give direct evidence of the presence of minute traces of various substances. This monograph lists 71 organic reagents and the elements for which they test. Each test is described in sufficient detail with references to the original literature. These tests represent selections made after careful trial of many tests in the B. D. H. laboratories. All reagents listed can be obtained in Great Britain. J.L.G.

Elementary Chemistry. A. H. B. BISHOP AND G. H. LOCKET. Oxford Univ. Press, London, 1936. 398 pp. Price 4s 6d. Briefly reviewed in *Nature*, **139** [3514] 394 (1937).—The text includes everyday applications of chemistry and classroom experiments and problems. J.L.G.

Semi-Micro Qualitative Analysis. CARL J. ENGELDER, TOBIAS H. DUNKELBERGER, AND WILLIAM J. SCHILLER. John Wiley and Sons, Inc., New York, 1936. x + 265 pp. Briefly reviewed in *Nature*, **139** [3514] 392 (1937).—Drop-reaction methods are applied to the ordinary system of qualitative analysis. 1 to 2 cc. of solution containing 20 mg. of material is sufficient for group separations and confirmatory tests. The book deals with the theoretical principles of qualitative analysis, the reactions of the cations of the various groups, "spot" tests employing organic reagents, the more common anions, and the systematic analysis of mixtures. J.L.G.

Textbook of Elementary Quantitative Analysis. CARL J. ENGELDER. John Wiley and Sons, Inc., New York, 1936. 2d ed. xiv + 270 pp. Briefly reviewed in *Nature*, **139** [3514] 393 (1937).—Volumetric, gravimetric, and electro analyses are covered for the beginning student from the standpoint of both theory and practice. J.L.G.

PATENTS

Defrothing of foam baths. J. JACKSON. Brit. 464,934, May 13, 1937 (Dec. 2, 1935).

Detergents and method of making. C. L. BAKER (Philadelphia Quartz Co.). U. S. 2,082,936, June 8, 1937 (June 21, 1934). The method of preparing a dry, stable mixture of a desired hydrated sodium metasilicate and a compatible hydrated sodium metaborate as herein disclosed comprises the following steps: (*a*) preparation of a solution calculated to satisfy the chemical requirements of the desired sodium metasilicate hydrate; (*b*) initiating crystallization of the sodium metasilicate hydrate and permitting it to continue until the mass becomes fairly thick; (*c*) adding the ingredients required to produce the composition of the desired compatible sodium metaborate hydrate while cooling, if necessary, to maintain the temperature below the melting point of the desired sodium metasilicate hydrate; and (*d*) initiating crystallization of the compatible sodium metaborate hydrate with further cooling, if necessary, to maintain the temperature below the melting temperature of the crystalline metasilicate and also below the transition point between the compatible crystalline metaborate and the crystalline metaborate of next higher melting temperature.

Method of antimony oxide production. J. O. BETTERTON (American Smelting & Refining Co.). Can. 364,029, Feb. 9, 1937 (Dec. 7, 1935). G.M.H.

Method of antimony trioxide production. J. O. BETTERTON AND R. D. MCLELLAN (American Smelting & Refining Co.). Can. 364,030, Feb. 9, 1937 (Dec. 28, 1935.). G.M.H.

Process of making alkali subsilicates. C. W. BURKHART AND W. S. RIGGS (Pennsylvania Salt Mfg. Co.). U. S. 2,083,545, June 15, 1937 (April 10, 1935). The process of preparing a solid alkali subsilicate comprises mixing together powdered silica and solid caustic alkali in such molecular proportions that the alkali oxide content of the mixture is not less than the silicon dioxide content and in the absence of sufficient water to dissolve a substantial portion of the caustic alkali present, and heating the mixture to a temperature below the fusion point of caustic alkali sufficient to cause the reaction between the silica and caustic alkali to form a subsilicate.

Red and yellow glaze compositions. ANDREW MALINOVSZKY AND A. L. BENNETT (Malinite Corp.). U. S. 2,083,033, June 8, 1937(Sept. 7, 1935). A ceramic frit for use with selenium and cadmium stains on ceramic bodies, capable of developing brilliant red, scarlet, and orange colors at maturing temperatures below about 2000°F, the frit containing from about 7.5 to 30% of B_2O_3, about 7.5 to 25% of PbO, about 5 to 12% of Na_2O, not more than about 10% of Al_2O_3, and not more than about 3% of F_2, the remainder being composed principally of silica and the frit being practically free from tin.

Zirconium opacifying pigment and method of making. C. J. KINZIE, J. A. PLUNKETT, AND C. H. COMMONS, JR. (Titanium Alloy Mfg. Co.). U. S. 2,083,024, June 8, 1937 (June 6, 1934). The method of making a composite opacifying pigment consisting of a stable, readily-powdered crystalline complex silicate containing zirconium oxide from 30 to 40% comprises heating a charge composed preponderatingly of zirconium silicate, lesser amounts of a compound of one element of the R_2O_3 group, two elements of the RO_2 group, one of which is zirconium oxide ranging from 30 to 40%, and a compound of at least one element of the RO group to substantially mutual decomposition and chemical reaction of the constituents of the charge to form a stable and readily pulverizable nonmetallic crystalline complex silicate bonded with a glass matrix, and milling the resulting product.

General

Course in glassmaking. D. R. *Verre & Silicates Ind.*, **8** [12] 142–43 (1937).—A course in glassmaking must include a study of the refractory materials in which the glass is prepared and on which it has a corrosive action. The rational and chemical analyses of the different mineralogical elements which constitute refractory clays and plasticity are treated here. See *Ceram. Abs.*, **16** [3] 86 (1937). M.V.C.

Robert Kennedy Duncan. ANON. *Bull. Amer. Ceram. Soc.*, **16** [6] 268–69 (1937).

Dust control. Present and future design considerations. THEODORE HATCH. *Mech. Eng.*, **57** [3] 154–56 (1935).—For successful dust control three things must be done: (1) The kinetic energy of the large particles must be destroyed. These particles are not important hygienically but they must be captured in order to prevent the escape of fine particles in the air stream created by their "drag." Their energy can be destroyed by means of barriers against which the particles impinge and lose their velocity, and the air currents induced by their motion can be dissipated by setting up counter currents in the zone of dust generation by means of air flow into the exhaust hood. (2) Air currents created by virtue of the operation of the dusty processes must be eliminated through changes in the machine, or more generally by the application of suitable baffles and housing to prevent their formation. (3) Air currents around the machine that can not be eliminated must be changed in direction and made to flow into the exhaust system. This is accomplished by means of the potential gradient established between the suction opening and the surrounding air. Through hood design, the gradient must be maintained at the proper slope from the area of dust production and at a minimum slope from the so-called ineffective areas in which no dust is produced. A knowledge of the aërodynamic characteristics of suction openings is therefore essential to proper design. F.G.H.

Mellon Institute of Industrial Research. ANON. *Bull. Amer. Ceram. Soc.*, **16** [6] 270–71 (1937).

Methods for controlling the dust hazard. A. D. BRANDT. *Metal Cleaning & Finishing*, **9** [4] 281–88 (1937).—Important methods for controlling the dust hazard are (1) control of harmful material at point of generation, (2) isolation of hazardous processes, (3) substitution of nonhazardous processes, and (4) reduction of dusts in inspired air by means of respiratory protective devices. Harmful dusts may be controlled at the point of generation by use of water or other suitable liquids, use of properly designed exhaust equipment, and good local housekeeping. Respirators found in industry today may be divided into three general classes: (*a*) mechanical filter respirators, which protect the wearer by filtering out atmospheric particulate matter from the inspired air; (*b*) chemical filter respirators, which protect the worker by neutralizing or absorbing harmful gases or vapors from the inspired air; and (*c*) supplied air respirators in which air from an uncontaminated source is forced to the wearer through tubing. All these control methods are thoroughly discussed. E.J.V.

Pottery for the Empire. ANON. *Trade & Eng.*, **41** [879] xlii (1937).—The best possible materials for pottery manufacture occur in the United Kingdom with the result that Staffordshire produces articles which are unequalled in texture and translucency. English tableware is distinguished for durability as well as style and is much used by steamship companies, restaurants, etc. Methods of firing, particularly in the use of town's gas and electricity for heating kilns and enamel furnaces, have been improved. The chief importer among the Dominions is Canada. No domestic porcelain is made in South Africa and majolica ware, chemical and electrical porcelain, and stoneware are all imported. Progress in the manufacture of refractory materials in the South Africa Union is reported and further developments in the manufacture of brick, pottery, tile, and electrical ware are being made. In Australia, the United Kingdom has a large share in providing imported earthenware, but competition by Japanese and continental manufacturers is keen. In spite of high tariffs and cost of freightage there is still a large export from the United Kingdom of sanitary ware, glazed tile, and electrical ware. A.B.S.

Scientific organization of works. P. CHEVENARD. *Metal Ind.* [London], **49** [12] 279–84 (1936).—The objectives of science in an industrial enterprise are to maintain and improve. This is the purpose of control, which prevents deviations in the process of manufacture, of expert investigations, which determine the cause of the inevitable failures, and of research. The task of a scientific director is manifold, difficult, and sometimes painful; to produce good work it is necessary for him to love his profession, to have an invincible faith in the fertility of methodical research, an obstinate tenacity, and the spirit of continuity. C. describes the impregnation of science into manufacture in the works of the Société de Commentry, Fourchambault et Decazeville. H.E.S.

Scientific research and modern industry. A. PORTEVIN. *Usine*, **46** [11] 25–27 (1937).—The interrelation and necessity of coöperation between industry and science is emphasized and conditions are discussed. M.H.

Toxic dusts. Their origin and sources in various industries. REUEL C. STRATTON. *Mech. Eng.*, **57** [2] 95–98 (1935).—S. briefly describes the origin and sources of dust in the production of flint and feldspar, cement and lime, brick, tile, terra cotta, glass, and enameled ware. F.G.H.

Use of fusible cones for the control of firing of ceramic products. JEAN MONTAGNE. *Rev. Matériaux Construction Trav. Publics*, No. 330, pp. 33–37B (1937).—Although the scientific value of the indications furnished by the fall of fusible cones under the influence of heat is being questioned, they will continue to be used for a long time because they are economical, easy to use, and permit the simultaneous control of numerous points of the furnace. For their indications to be of value, the cones must be properly used; this is more often the cause of the failure of the cones than is the faultiness of the cones themselves. The following rules are given to obtain exact indications with fusible cones: (1) A refractory support should be used consisting of a mix of refractory clay and grog with a shrinkage of from 1 to 3%. (2) Mounting the cones: the edge opposite the side bearing the inscriptions (number and mark) should be vertical. Large cones should be sunk into the support 3 to 4 mm., and small cones, 2 to 3 mm. (3) Placing and protection of cones in the furnace: (*a*) the cones must be protected from the direct action of the flames, *e.g.*, placed in a sagger, (*b*) they must be uniformly heated on all sides, and (*c*) nearness to sudden heat or cold (opening of sight holes) should be avoided. (4) Controlling the fire: (*a*) a regular temperature curve and steadily rising temperature should be sought, and (*b*) for cones below 015a, reducing atmosphere should be avoided. M.V.C.

Fortieth Annual Meeting
AMERICAN CERAMIC SOCIETY
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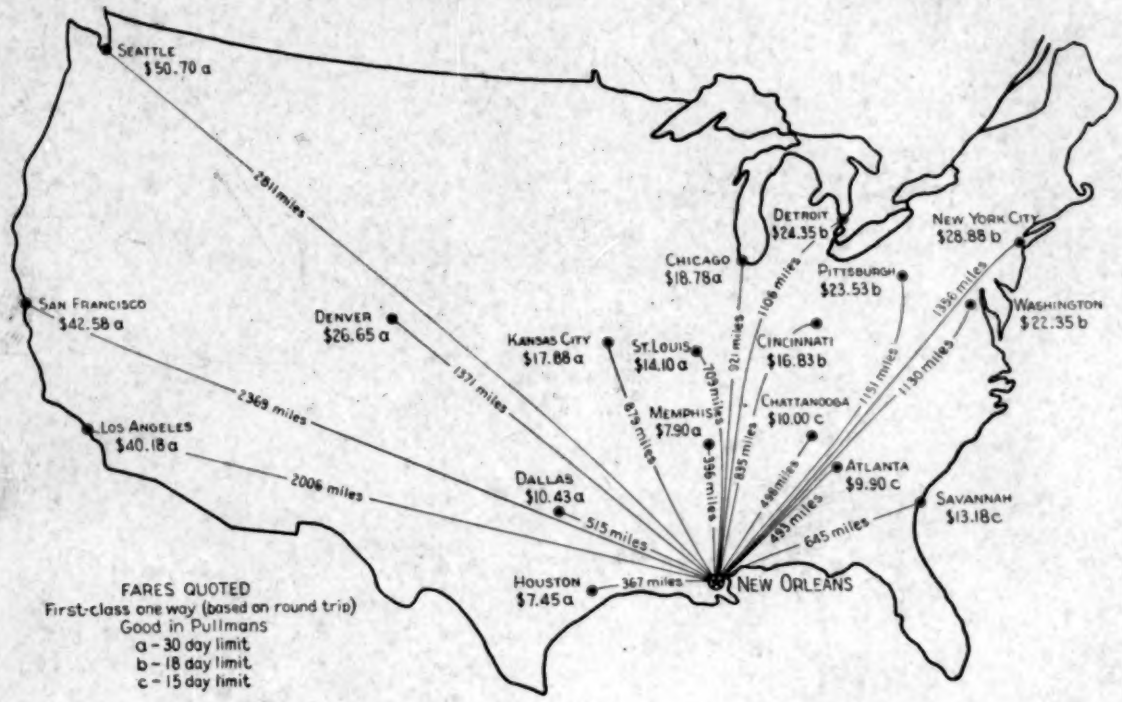

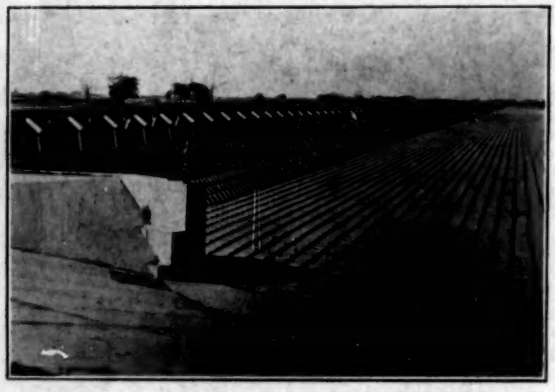

Bonnet Carre Spillway

The Bonnet Carre spillway, 32 miles above New Orleans. Built by U. S. Army Engineers to take water from the Mississippi River to Lake Pontchartrain.

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